SILURIAN AND DEVONIAN CRINOIDS FROM CENTRAL VICTORIA

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Crinoids have long been known from middle Palaeozoic clastics in central Victoria but this is the first comprehensive attempt to document the fauna; 54 taxa are described; 25 are camerates (ca), 7 disparids (d), 19 cladids (cl) and 3 flexibles (f). New taxa are the genera *Hollowaycrinus calvus* (ca), *Duncanicrinus calvariolus* (ca), *Frankocrinus holmesi*, *F. enidae* (ca), Pterinocrinidae gen. nov. (ca), *Darraghcrinus tomi* (d), *Kroppocrinus heathcotensis*, *K. mathiesonensis* (d), *Stewbrecrinus terryi* (cl), *Holmesocrinus enidae*, *H. idaensis* (cl) and *Quadritaxocrinus websteri* (f); camerate species *Ophiacrinus mettae*, *Dimerocrinites bispinosa*, *Eucrinus clarkae*, *Eudimerocrinus ekardti*, *E. gilli*, *Nexocrinus wallanensis*, *Hexacrinites chirnsidensis*, *Oehlerticrinus lemenni*, *O. jeani*, *Alisocrinus lineatus*, *Clematocrinus perforatus* and *C. argylensis*; disparid species *Trichocrinus morleyi* and *Phimocrinus hanschi*; cladid species *Codiacrinus secundus*, *Cupulocrinus austrogracilis*, *Dendrocrinus artugius*, *Plicodendrocrinus australis*, *Shintocrinus cometensis*, *S. richi*, *Antihomocrinus chapmani*, *Nassoviocrinus corcorani*, *Dictenocrinus ibaeypus* and *D. remotus*; and the flexible *Meristocrinus quatriramus*. ☐ *Crinoids, Silurian, Devonian, Victoria.*

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Middle Palaeozoic sequences in the Melbourne Trough of central Victoria have yielded rich fossil faunas since the middle of last century but the diverse crinoid component has been largely ignored among echinoderm groups (Withers & Keble, 1934a and b; Jell, 1983). Possibly the first record and certainly the first illustration of crinoids from central Victoria was that of Blandowski (1855) but he figured only stem columnals and did not follow with the descriptive paper promised. Bather (1897) first described an articulated crinoid, *Hapalocrinus victoriae*, with a line drawing that he acknowledged in a footnote as being somewhat uncertain. Photographs of Bather's (1897) specimen and its counterpart (Bather claimed it was lost) are provided below and show that the cup is poorly known. Chapman (1903) described *Helicocrinus plumosus* and *Botryocrinus longibrachiatus* from the Silurian of the Melbourne area. Both are reviewed below with the latter re-assigned to *Nassoviocrinus* Jaekel, 1918.

More recent reports of crinoids in clastic sequences of central Victoria are restricted to : 1. Talent (1965;17, pl. 4, fig. 2) noted crinoid stem ossicles as a common element throughout the Heathcote sequence and crowns at localities 41 (=*Hapalocrinites argylensis* sp. nov., below) and 42 from where he figured the unidentifiable external mould of a crown; 2. *Crotalocrinites* from Heathcote (Jell, 1982) and; 3. *Kooptoonocrinus nutti*, *Codiacrinus rarus*, *Dendrocrinus saundersi* and a new genus of Dimerocrinitidae (=*Duncanicrinus calvariolus* below) from near the Silurian/Devonian boundary east of Melbourne (Jell in Jell & Holloway, 1983). Numerous other records of crinoids in these sequences (e.g. Williams, 1964; Gill & Caster, 1960) simply noted them among wider faunal listings without naming or describing taxa. Other described crinoids from Victoria occur in limestones at Lilydale (Bates, 1972), Mansfield (Jell et al., 1988) and Toongabbie (Philip, 1961). In the rest of Australia, Devonian crinoids have been described from limestones in Queensland and NSW (Jell et al., 1988) and *Pisocrinus* (referred to *Parapisocrinus* by Rozhnov, 1981) and *Lecanocrinus* have been reported from the Silurian at Yass (Etheridge, 1904; Chapman, 1934).

BIOSTRATIGRAPHY

The sections from which these crinoids have been collected span the Ludlow and Pridoli of the Silurian and the Lochkov of the Devonian. However, soil cover, urban development and metamorphism around intrusions limit available sections. Virtually all the echinoderms known have been collected from quarries, road cuttings, creek beds or other man-made exposure.

Wenlock	Ludlow				Prid-oli	Lochkov						Pragian
	Aegiria thomasi			*Not. Plentiensis*		*Boucotia janeae*			*Boucotia australis*			
	1	2	3	4	5	6	7	8	9	10	11	
Dendrocrinus sp.	X	O	O		O							*Trichocrinus morleyi*
Dendrocrinus arrugius		X	X	X					X		O	*Hollowaycrinus calvus*
Nassoviocrinus corcorani		X	X						O		O	*Ctenocrinus signatus*
Hapalocrinus victoriae		X							O	O	O	*Ctenocrinus paucidactylus*
Helicocrinus plumosus		X							O			*Dimerocrinites bispinosus*
Nassovio- longibrachiatus		X							O			*Eucrinus clarkae*
Phimocrinus americanus		X									X	
Clematocrinus argylensis		X		O					O			*Clematocrinus perforatus*
Alisocrinus lineatus				X							O	*Frankocrinus holmesi*
Phimocrinus hanschi				X					O			*Frankocrinus enidae*
Shintocrinus cometensis				X	O				O		O	*Duncanicrinus calvariolus*
Antihomocrinus chapmani				X			X		X		X	
Quadritaxocrinus websteri				X					O			*Nexocrinus* sp.
Holmesocrinus enidae					X				O			*Plicodendro- australis*
Nexocrinus wallanensis					X						O	*Stewbrecrinus terryi*
Kroppo- heathcotensis		X							O		X	*Codiacrinus secundus*
Cupulo- austrogracilis						X				O		*Holmesocrinus idaensis*
Hexacrinites chirnsidensis							X		O			*Darraghcrinus tomi*
Ophiocrinus nnettae								X			O	*Kroppo- mathiesonensis*
Eudimerocrinus gilli								X			O	*Meristocrinus quatriramus*
Ctenocrinus stellifer							X	X	X		O	*Decacrinus* sp.
Dictenocrinus remotus								X			O	*Ancyrocrinus* sp
Dictenocrinus ibaeypus									X	O		*Crotalocrinites pulcher*
Kooptoonocrinus nutti					X				O		O	*Eudimerocrinus eckardti*
Geroldicrinus sp.								X	O		O	*Oehlerticrinus lemenni*
Shintocrinus richi								X	O		O	*Oehlerticrinus jeani*
Pterinocrinidae gen. nov								X			O	Myelodactylid indet.
Dendrocrinus saundersi					X							
Codiacrinus rarus					X							

FIG. 1. Distribution of crinoids in the Silurian-Devonian clastic sequences of central Victoria; all species listed are dealt with in this paper, Jell & Holloway (1983) or Jell (1982). The international scale is correlated to the local Brachiopod Assemblage Zone scheme of Garratt (1983) in the top two rows, following Garratt & Wright (1988). The numbering sequence of columns in the third row refers to aggregates of localities as listed in the Appendix; detailed relative levels of widely distributed localities is uncertain and these must be seen in many cases as best approximations. Occurrence of taxa listed on the left of the figure are indicated with 'X' and those on the right by 'O'. Generic names ending in a hyphen require addition of the suffix *crinus* and are shortened to fit a single line.

Structure within the Melbourne Trough consists of tight folding with long approximately N-S axes, also limiting measurable sections. Fossils occur in profusion in a few horizons; they are relatively rare in many other horizons; but most of the sedimentary sequence is unfossiliferous. Brachiopods are the most common group among the shelly fauna and have been used to establish a preliminary biozonation (Fig. 1) against which the shelly faunas have been placed in sequence (Garratt, 1983). The crinoids described herein come mainly from the few horizons where fossils are prolific and preservation is superb; very large numbers of articulated echinoderms occur there. For example, NMVPL252 provides the greatest diversity of crinoids and of echinoderms in the Melbourne Trough. This locality was originally a small road metal quarry but most available material came from a new excavation of the quarry in the summers of 1980-1983 undertaken by the author with the sustained help of Frank and Enid Holmes and Steve Eckardt and occasional help of several others. Those localities that yield only one or 2 species mostly represent localities where fossils are rare and their age determined by stratigraphic position. The crinoid localities (Appendix) are placed in approximate relative stratigraphic sequence (Fig. 1) using these best available data. The brachiopod zonation of Garratt is related to the international stage scale with graptolites that occur at a few horizons through the sequence (Garratt & Wright, 1988).

The crinoids described herein are not significantly useful biostratigraphically as they occur relatively rarely in terms of both localities and horizons. Nevertheless there are clear differences between the Ludlow and Lochkov faunas for example and the continued study of this fossil group with other elements of the shelly fauna will continue to refine what is at present a very preliminary brachiopod zonation.

PALAEOECOLOGY

Palaeoecological settings in the Melbourne Trough were discussed in a number of papers (Garratt, 1983; Cas, 1983; Vandenberg & Wilkinson, 1982; Vandenberg, 1988, 1992). Cas (1983, fig. 17) provided a schematic diagram of regional palaeogeography for SE Australia showing the Melbourne Trough as a long narrow embayment of the ocean with ample neighbouring relief and continued subsidence to provide the thick pile of clastic sediments. Localities rich in articulated echinoderms occur in distal turbidites (PL252) or extensive thin sand units (within a finer grained sequence) (PL300, 229, 1924). Both these settings indicate catastrophic events causing the death and fast burial of these animals (Jell, 1983) but the cause or causes of such events remain unclear.

PALAEOBIOGEOGRAPHY

These crinoid faunas provide few useful data for palaeobiogeographic reconstruction as they contain taxa otherwise restricted to North America or to Europe and other taxa common to both those areas. Few other parts of the world have well enough described crinoid faunas of this age for meaningful comparison. At the generic level there are slightly more representatives of the European fauna as is the case with brachiopods (Boucot et al., 1969) but among camerates there are more American affinities.

SYSTEMATIC PALAEONTOLOGY

Material described is housed in the Museum of Victoria (NMVP) and the localities are registered in the same Museum (NMVPL). Specimens are preserved in decalcified clastics so are found in the form of internal and external moulds often partially infilled with iron oxides making the mould less than faithfull. Morphological detail of the moulds improves with diminishing grain size of the matrix. All illustrations are of latex casts taken from these moulds and whitened with a sublimate of ammonium chloride. Terminology follows Moore & Teichert (1978). Measurements are given as: length, parallel to the central axis; width, transverse to, but never cutting or meeting the central axis; and depth, normal to, and may join the central axis.

Class CRINOIDEA Miller, 1821
Subclass CAMERATA Wachsmuth & Springer, 1885
Order DIPLOBATHRIDA Moore & Laudon, 1943
Suborder EUDIPLOBATHRINA Ubaghs, 1953
Superfamily RHODOCRINITOIDEA Roemer, 1855
Family OPSIOCRINIDAE Kier, 1952

Frest & Strimple (1981) and Ausich (1986a) recognised the close similarity of *Opsiocrinus* Kier, 1952 and *Ophiocrinus* Salter, 1856 and assigned them both to this family; they are considered synonymous by Jell & Theron, 1999. Ausich (1986a) also erected 2 new genera from the Llandovery of Ohio in this family and discussed the group in detail. Inclusion of the Australian *Hollowaycrinus* nov. is discussed under that heading below. This addition necessitates widening the family concept to include a form with radials in lateral contact; this difference has been sufficient to separate taxa at superfamily level in the past (Ubaghs, 1978b). To take an even more heretical view I question whether *Stelidiocrinus* Angelin, 1878 from the Upper Silurian of Gotland should not be included in this family. It has been classified in the Monobathrida because it lacks the second circlet of plates below the radials but it (particularly *S. laevis* Angelin, 1878 as figured by Ubaghs (1978b, fig. 307, 1e)) resembles the Opsiocrinidae very much in cup shape, median column of anal plates in CD interray, 10 biserial arms, few slightly depressed interradial plates and presence of an intersecundibrach. Its first primibrach is shorter and wider than in most Opsiocrinidae but is comparable with that of *O.*

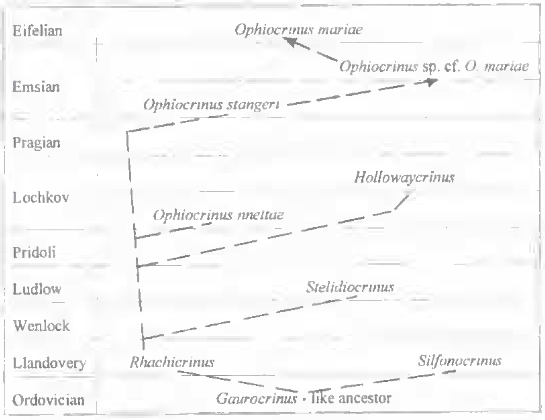


FIG. 2. Sketch of phylogeny of the Opsiocrinidae following Ausich (1986a) and discussion herein.

nnettae described below. Throughout the Opsiocrinidae the infrabasals are concealed by the stem attachment and *Opsiocrinus* itself was originally described as monocyclic; I suggest therefore, that a careful examination of the Swedish material of *Stelidiocrinus* should be made to determine this feature. *Stelidiocrinus* would join *Hollowaycrinus* as the second Opsiocrinidae with radials in lateral contact. Witzke & Strimple (1981) suggested that evolution from rhodocrinitid to dimerocrinitid stage (i.e. withdrawl of the first interbrachial to allow lateral contact of radials) occurred several times. They postulated 3 separate occasions from different *Ptychocrinus* stocks so my suggestion of 2 further occasions above is in line with their thinking.

Current knowledge of this family suggests that only small sections of the lineages involved are known (Fig. 2) and I agree with Witzke & Strimple (1981) that a great deal more basic data about Silurian forms in particular will be necessary to refine our understanding.

Ophiocrinus Salter, 1856

TYPE SPECIES. *Ophiocrinus stangeri* Salter, 1856 from the Lower Devonian Bokkeveld Series, South Africa.

REMARKS. This genus is discussed in detail elsewhere (Jell & Theron, 1999). Its occurrence in the Lower Devonian of Victoria in close proximity geographically and temporally with *Hollowaycrinus* gen. nov. makes it quite feasible that one gave rise to the other as remarked under that genus below.

Ophiocrinus nnettae sp. nov.
(Fig. 3)

ETYMOLOGY. An anagram from Annette.

MATERIAL. NMVP149344 from NMVPL1990.

DIAGNOSIS Interrays narrow; primanal in posterior interray contacting C and D radials and 1st primibrachs, supporting 3 anal plates distally; central column of larger hexagonal plates in anal sac. Arms 10, with triangular axillary 2nd primibrach, distinctly biserial above distal to secundibrach. Stem circular, with small but distinct marginal projections on nodals and internodals.

DESCRIPTION. Crown >40mm long, >4 times as long as wide at cup, with arms spreading gently (tips not preserved). Cup low conical, approximately 5mm long, wider than long; plates smooth, convex so sutural margins depressed. Infrabasals presumably concealed by stem. Basals longer than radials, hexagonal, longer than wide. Radials pentagonal, wider than long, separated from each adjoining radial by basals and 1st interprimibrach, with distinctly margined outer ledge across distal margin matched by similar ledge on 1st primibrach, similar matching ledges on succeeding interplate sutures along the arm gradually diminishing in distinctness and size; 1st primibrach rectangular, as wide as radial, short; 2nd primibrach axillary, triangular, as wide as 1st primibrach. Arms 10, subquadrate in section, with flattened outer face; each ray with 2 main rami, uniserial as far as 6th secundibrach, becoming biserial abuptly (3rd in one arm observed) distally, with long pinnule of 5 or 6 pinnulars on each free brachial; only primibrachs fixed in cup; interprimibrachs small and few; 1st largest, contacting basal, 2 radials and 1st primibrachs, supporting 2 long narrow plates distally. Primanal hexagonal though contacting 8 plates, almost as large as basals but not quite as long, supporting 3 anals distally; anal plates numerous, decreasing in size distally, with average size larger than that of interbrachials, distinct central column of decreasing hexagonal plates. Stem circular in section, heteromorphic with slightly different sized (length and diameter) columnals alternating, noditaxis N1, with epifacet on each columnal having an outer circlet of small but distinct tubercles or pseudocirri.

REMARKS. This Victorian species differs from the South African genotype (Jell & Theron,

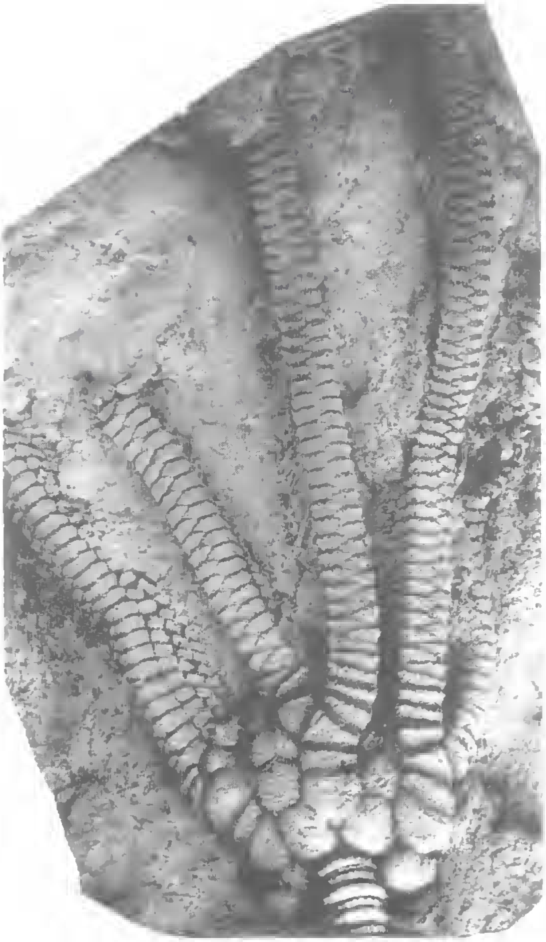


FIG. 3. *Ophiocrinus nnettae* sp. nov., incomplete holotype crown in C ray view, NMVP149344 from NMVPL1990, ×3.

1999) in having fewer interprimibrachs, no intersecundibrachs, distinct ledges on each plate on each interplate suture from radials up to about 3rd secundibrach, its arms becoming biserial much earlier (secundibrach 3 in some arms) and in the stem with tubercles on internodals. From the North American *O. mariae* Kier, 1952 and *O. benderi* (Kesling, 1968), if those are separate species as suggested by Frest & Strimple (1981) contrary to Kesling & Chilman (1975), the Victorian species is distinguished by the same features as separate the genotype as well as a lack of ornament on the interprimibrachs and very short 1st primibrach.

Hollowaycrinus gen. nov.

TYPE SPECIES. *Hollowaycrinus calvus* sp. nov.

ETYMOLOGY. For David Holloway who greatly assisted with fieldwork, curation and scientific advice.

DIAGNOSIS. Infrabasals 5, concealed by stem attachment. Radials large, heptagonal, in contact with each other laterally except across CD interray; 1st primibrach hexagonal; 2nd primibrach axillary. Primanal in radial circlet, supporting 3 plates distally, with median column of larger anal plates involving 4 and probably more plates. Arms 10-20, with each ray having 2 main arms becoming biserial distal to the 6th or 8th secundibrach, with some arms branching irregularly once or twice distal to primaxil even though other rami in the same individual are unbranched.

REMARKS. This genus is placed in the Opsiocrinidae based on the similarities in cup shape, 5 concealed infrabasals, median column of anal plates in CD interray, primanal supporting 3 plates, large 1st interprimibrach supporting 2 plates followed by large number of very small irregular plates, 10-20 arms, uniserial to biserial. Conventional classification following Ubaghs (1978) would place this species in *Dimerocrinites* because of the radials being in lateral contact. However, the arms being uniserial proximally then becoming cuneate and finally biserial, the interradial plates being many small ones above a few large ones and the radials being barely in lateral contact all point to an origin from the Opsiocrinidae and it is classified accordingly.

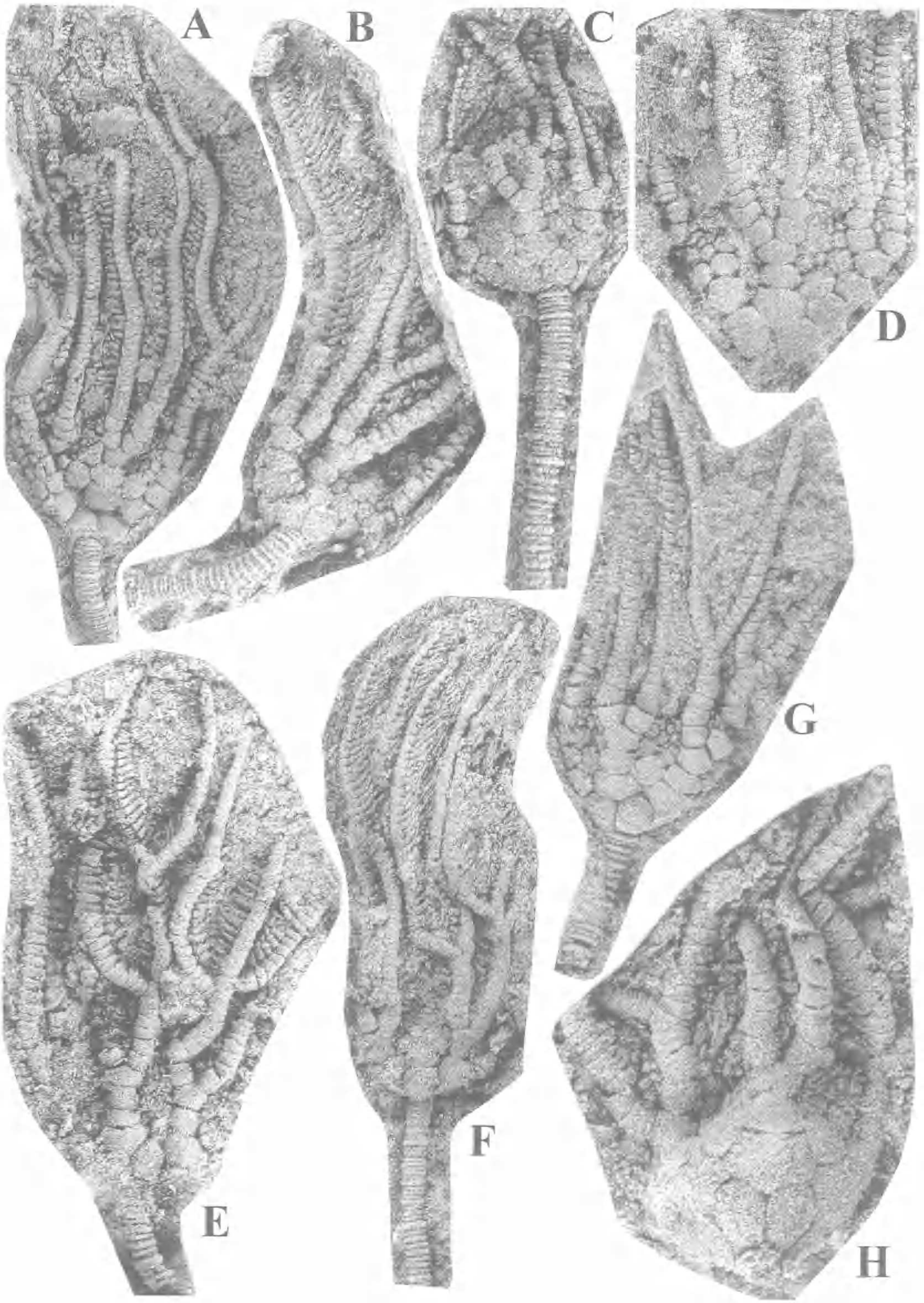
Hollowaycrinus calvus sp. nov.
(Fig. 4)

ETYMOLOGY. Latin *calvus*, bald; referring to the lack of median ray ridges and ornament.

MATERIAL. HOLOTYPE: NMVP100158. PARATYPES: NMVP100150, 100153, 107099-107104, all from NMVPL229.

DIAGNOSIS. As for genus.

DESCRIPTION. Crown subcylindrical, averaging 30mm long, at least 4 times as long as wide. Cup low to medium conical, 2-6mm long, just wider than long, of unornamented plates. Infrabasals 5, concealed by stem. Basals 5, longer than radials, hexagonal except for heptagonal posterior one, longer than wide. Radials heptagonal, wider than long, with longer sides contacting basals and 1st primibrach, with short sides contacting adjoining radials or primanal in CD interray; 1st primibrach hexagonal, not as wide as radial and little more than half as long;


A
B
C
D
G
E
F
H

2nd primibrach axillary, pentagonal, as wide as 1st primibrach; each ray with 2 main arms, some without further branching, others with 1 or 2 further branchings irregularly, uniserial as far as 6th or 8th secundibrach, becoming biserial distally, with long pinnule of 5-6 pinnulars on each free brachial; arms free distal to 2nd secundibrach; interprimibrachs numerous, with large heptagonal proximal one supporting 3 plates in a row distally, with size decreasing rapidly distally, with distal medial plates depressed. Primanal hexagonal, almost as large as basals, supporting 3 anals; anal plates numerous, decreasing distally, with average size larger than interprimibrachs. Stem circular in section, with slightly different sized (length and diameter) nodals and internodals alternating proximally but distally with noditaxis N212, may be long (no complete stem known but an incomplete one in excess of 9cm known), distal termination unknown. All plates smooth, without ornament.

REMARKS. This species is distinguished from *Ophiocrinus* by most radials just making lateral contact and by variable arm branching. Its separation from dimerocrinitids is discussed above. The arms are highly variable in their branching pattern and also in the arrangement of brachials. Most observable rays divide once and have only 2 arms whereas others may have one undivided arm from the first branching while the second may divide twice more. Most subsequent divisions appear to be at fairly high and variable angles to growth direction; there is a question of whether these could represent a regrowth response to breakage or predation to which no answer is readily available. Brachials begin to become cuneate just distal to the cup and in most cases become biserial cuneate by about the 8th secundibrach; a few remain cuneate farther distally and none become rectilinear biserial.

Superfamily DIMEROCRINITOIDEA Zittel, 1879

Family DIMEROCRINITIDAE Zittel, 1879

This family is a regular component of crinoid faunas from Ordovician to Devonian and has been discussed by many authors (Ausich, 1986a; Brower, 1973; Breimer, 1962; Frest & Strimple, 1981; MacIntosh, 1981, 1987; Witzke & Strimple, 1981 among others). Since most that is known about this family comes from the Northern Hemisphere it is outside my aims to review its phylogeny. However, in adding the several Australian forms that follow I have had to make some inferences about Northern Hemisphere taxa. The simplest way to recognise members of the family until recently had been to identify that a crinoid was dicyclic and that its radials were all in contact except for interrupion by the primanal in the CD interray. Witzke & Strimple (1981) questioned the universality of this single feature and I agree with their discussion of evolution between the Rhodocrinitoidea and Dimerocrinitoidea. In assigning *Hollowaycrinus* to the Opsiocrinidae and suggesting that *Stelidiocrinus* may also belong to that family I follow their line of thought. I also follow Witzke & Strimple (1981) in the generic divisions of the family based on numbers of arms (Fig. 5) although there is good reason to believe that numbers of arms may have changed on several parallel lineages within the family.

Moving along Witzke & Stimple's (1981) ideas we now have available generic names for dimerocrinitoids with uniserial arms that divided once (*Duncanicrinus* gen. nov.), twice (*Nexocrinus* Eckert, 1984) or more than twice in each ray (*Ptychocrinus*) and for biserial representatives with 10 (*Dimerocrinites*), 20 (*Encrinus*) or more than 20 arms (*Eudimerocrinites* (=*Ambicocrinus*), *Griphocrinus*). Whether latest Ordovician *Ptychocrinus fimbriatus*, Llandovery *P. longibrachialis* and Early Devonian *Duncanicrinus* constitute a lineage or not will only be answered by gaining further knowledge of Silurian taxa and thus detailed phylogenies but at present this is a reasonable hypothesis worth further testing (Fig. 5). These generic groupings accommodate Brower's (1973) idea that the 3 latest Ordovician species of *Ptychocrinus* represented 3 separate lineages and should be separated generically and Witzke & Strimple's (1981) ideas on the existence of 3 lineages in the Dimerocrinitidae based primarily on numbers of arms. There are no doubt numerous exceptions to these general groupings and the most obvious is the high probability that the transition from uniserial to biserial arms occurred more than once in each lineage. However, it is necessary to continue assimilating new data into an hypothesis

FIG. 4. *Hollowaycrinus calvus* gen. et sp. nov., all crowns with or without stem attached, from NMVPL229. A, NMVP107101, ×2.5. B, holotype, NMVP100158, ×4. C, NMVP100150, ×5. D, NMVP100153, ×4. E, NMVP107102, ×3.5. F, NMVP107104, ×3.5. G, NMVP107103, ×3. H, NMVP107099, ×5.

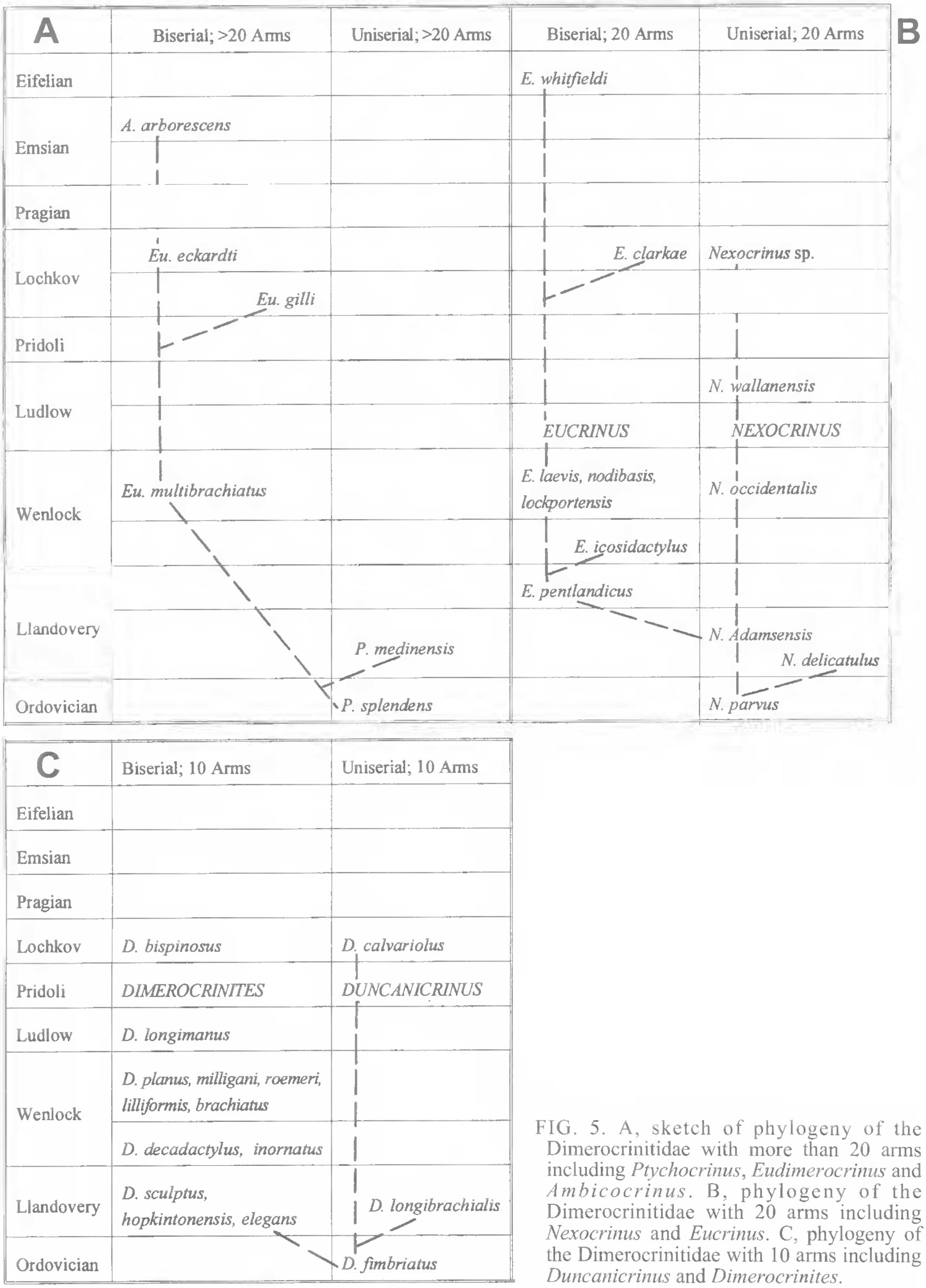


FIG. 5. A, sketch of phylogeny of the Dimerocrinitidae with more than 20 arms including *Ptychocrinus*, *Eudimerocrinus* and *Ambicocrinus*. B, phylogeny of the Dimerocrinitidae with 20 arms including *Nexocrinus* and *Eucrinus*. C, phylogeny of the Dimerocrinitidae with 10 arms including *Duncanicrinus* and *Dimerocrinites*.

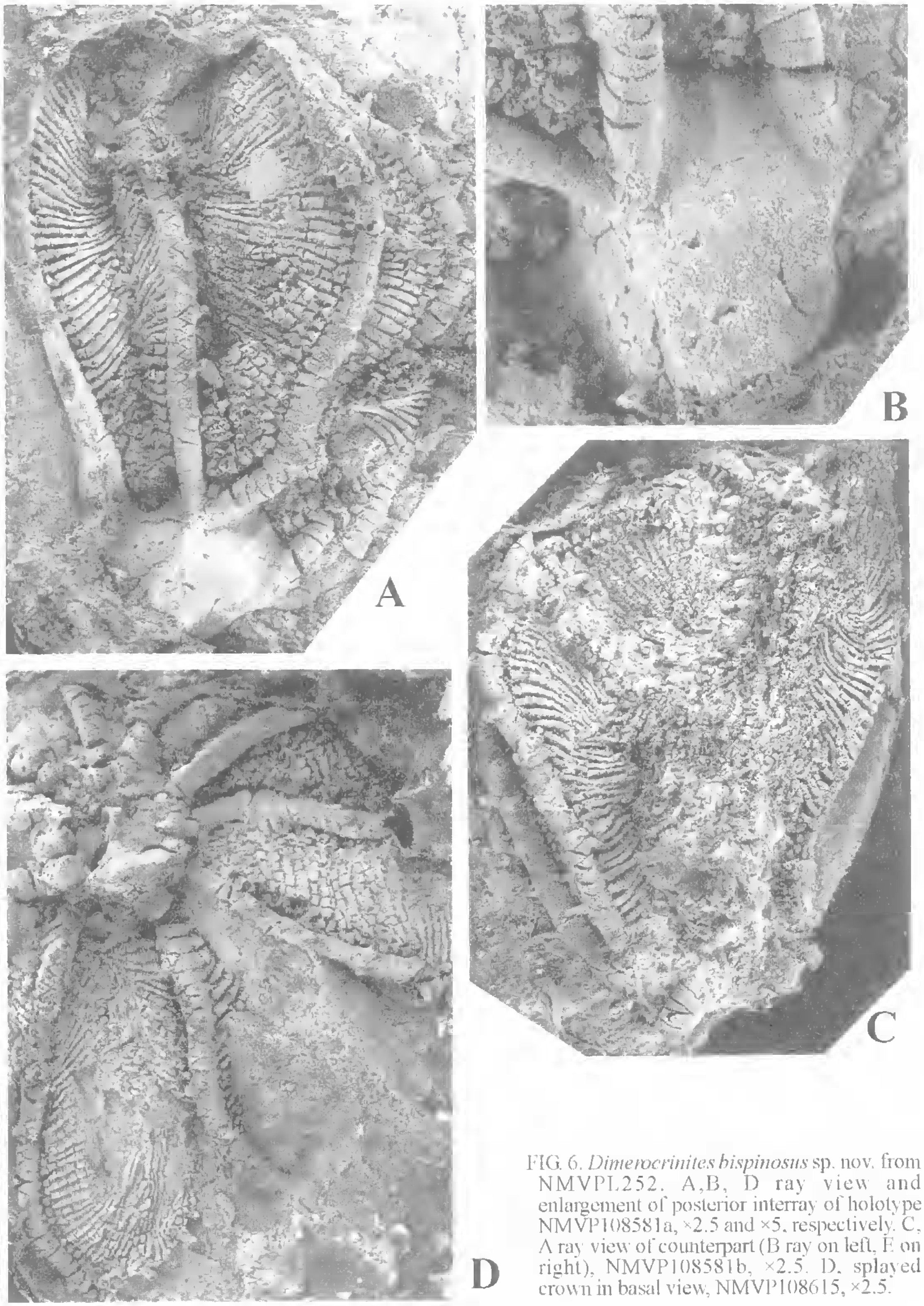


FIG. 6. *Dimerocrinites bispinosus* sp. nov. from NMVPL252. A,B, D ray view and enlargement of posterior interray of holotype NMVP108581a, ×2.5 and ×5, respectively. C, A ray view of counterpart (B ray on left, E on right), NMVP108581b, ×2.5. D, splayed crown in basal view, NMVP108615, ×2.5.

until all the details are worked out. To that end I offer a possible phylogeny (Fig. 5) for known species of Dimerocrinitidae for future testing and modification where necessary. Just how many lineages and which features remained constant to be able to recognise separate lineages remain largely unanswered for the dimerocrinitids today as when Witzke & Strimple (1981) raised many questions on the origins of their groupings.

Dimerocrinites Phillips in Murchison, 1839

TYPE SPECIES. *Dimerocrinites decadactylus* Phillips in Murchison, 1839 from the Wenlock of England; by subsequent designation of Roemer, 1855.

REMARKS. I apply the concept of Witzke & Strimple (1981) to *Dimerocrinites (Dimerocrinites)* which is to restrict the genus to those forms of the broader generic group with 10 arms.

Dimerocrinites bispinosus sp. nov.
(Fig. 6)

ETYMOLOGY. Latin *bi-*, two and *spinosus*, spine, for the pairs of spines on the outer sides of arms.

MATERIAL. HOLOTYPE: NMVP108581. PARATYPE: NMVP108615 from NMVPL252.

DIAGNOSIS. Ten arms, with prominent regularly spaced pairs of spines every fifth brachial on outer face, with hexagonal intersecundibrach, with low but distinct anitaxis of hexagonal plates.

DESCRIPTION. Crown subcylindrical, up to 45mm long, up to 4 times as long as wide. Cup subconical, about 1cm long, longer than wide, with convex tegmen; cup plates thin, smooth. Infrabasals concealed by stem. Basals pentagonal, except for hexagonal posterior one, with narrowest proximal margin forming part of circular rim to basal concavity, about as long as wide, with marked proximal medial projection (suggesting a pentagonal stem with the angles of the stem in the centres of basals beneath this projection), with Y-shaped median ray ridge dividing about midlength and extending onto adjacent radials. Radials heptagonal, much wider than long, with inverted Y-shaped ray ridge, with arms of this Y running onto adjacent basals. First 2 secundibrachs fixed in cup. Arms 10, of uniform cross section through available arm length; 1st primibrach hexagonal, not as wide as radial and little more than half as long; 2nd primibrach axillary, heptagonal; each arm uniserial with cuneate brachials as far as 6th or 8th secundibrach, biserial distally, with pair of strong solid spines on outer surface of rami placed about every 5 brachials; pinnules on each free brachial (i.e. distal to 2nd secundibrach) on each side of ramus, long, of 8-12 pinnulars. Interprimibrachs numerous, with heptagonal proximal one supporting 2 plates of about the same size, with size decreasing rapidly distally. First intersecundibrach hexagonal, subsequent plates not clear but presumably part of tegmen. Posterior interray with central anitaxis of hexagonal plates; hexagonal primanal supporting 3 anals in next row; anal plates numerous, decreasing distally, with average size smaller than that of interbrachials. Stem unknown.

REMARKS. With 10 biserial arms this species is placed in *Dimerocrinites* of Witzke & Strimple (1981) and is distinguished within that taxon by the spines on the outer arm faces, long hexagonal intersecundibrachs and the heptagonal axillary 2nd primibrach.

Eucrinus Angelin, 1878

TYPE SPECIES. *Eucrinus laevis* Angelin, 1878 from the Wenlock of Gotland; by subsequent designation of Wachsmuth & Springer, 1881.

REMARKS. This taxon is used in the sense of Witzke & Strimple (1981) to include species of *Dimerocrinites* with 20 arms; there seems little point in maintaining subgeneric distinction since we have no clear idea of phylogeny among these many species and when lineages are established it seems likely that both *Dimerocrinites* and *Eucrinus* will prove to be polyphyletic. The Victorian species is assigned on the basis that all rays countable have 4 arms except for one which has 5 and is considered aberrant; thus a total of 20 arms would be expected if branching is uniform.

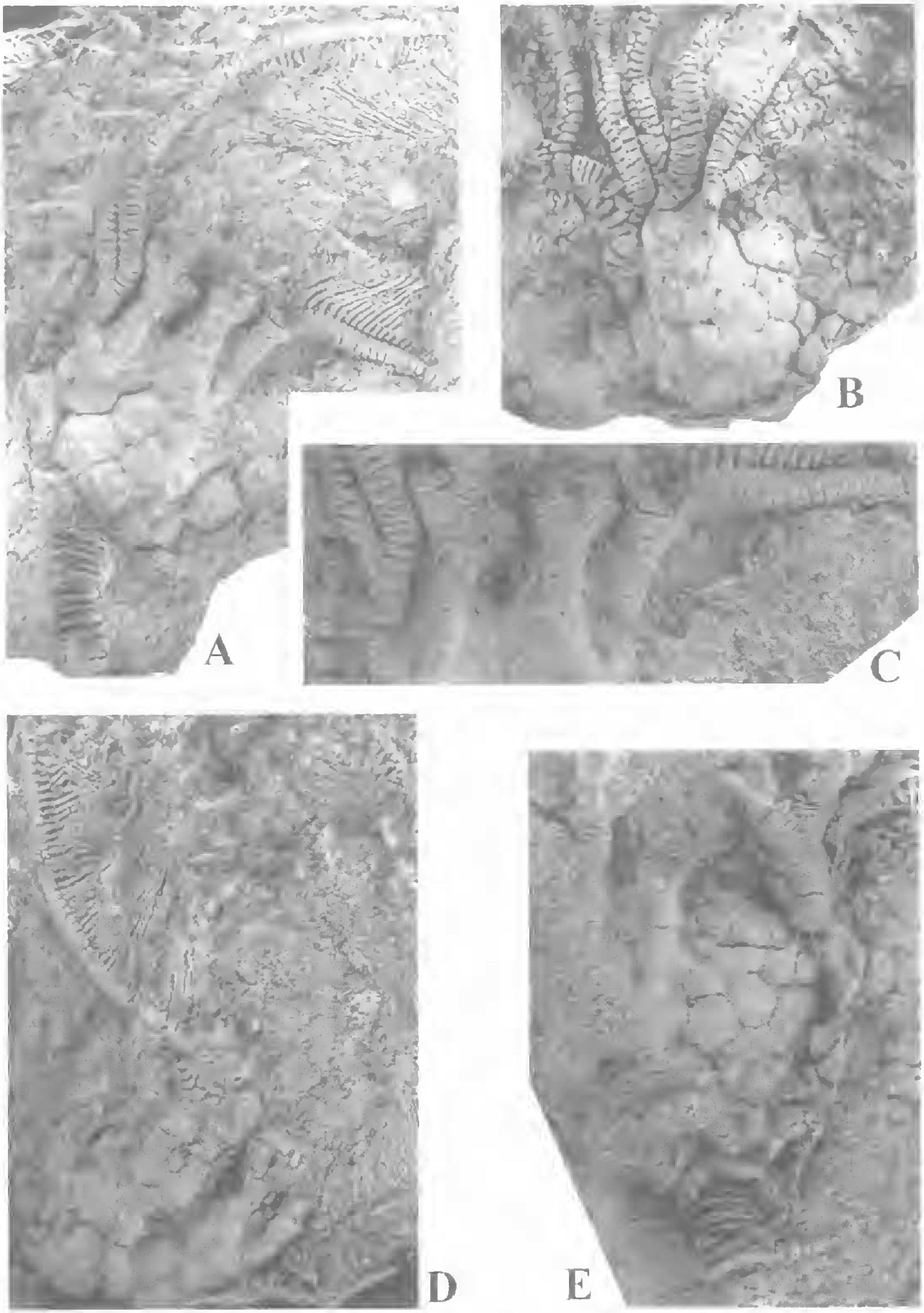
Eucrinus clarkae sp. nov.
(Fig. 7)

ETYMOLOGY. For Penny Clark who helped greatly with photography, curation and fieldwork.

MATERIAL. HOLOTYPE: NMVP108642. PARATYPES: NMVP108643, 108645 all from NMVPL252.

DIAGNOSIS. Basals, radials and radianal with distinctive coarse ornament of short fat radial

FIG. 7. *Eucrinus clarkae* sp. nov. all from NMVPL252. A,C, lateral view of crown with stem and enlargement of distal cup and proximal arms of NMVP108645a, ×2.5 and ×4, respectively. B, lateral view of NMVP108643, ×2. D, lateral view of NMVP108645b, ×2.5. E, CD interray view of holotype NMVP108642, ×4.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ridges normal to sutures and not joining centrally on plates. Crown with fine granulose ornament throughout. Intersecundibrachs few, in narrow vertical column, one in each row. Arms free distal to about 3rd tertibrach, uniserial proximally, secundibrachs becoming irregularly cuneate distally, tertibrachs becoming rectilinear biserial distal to about the 9th or 10th. Proximal brachials with distinctive fine ridge along proximal and distal margins. Stem round in section.

DESCRIPTION. Crown flaring gently distally, up to 60mm long. Cup high bowl-shaped, of large thin plates, up to 15mm long. Infrabasals concealed by stem (fragments evident in holotype between basals and stem but arrangement or number not available). Basals 5, with 4 of them pentagonal and posterior one larger and hexagonal, with proximal margin raised into prominent rim to basal cavity and stem, with conspicuous nodes representing ray ridges 2 per infrabasal directed towards middle of sutures with contiguous basals but 3 on posterior basal (central one vertical in middle of posterior interray). Radials 5, heptagonal except for hexagonal posterior one, largest plates in cup, with inverted Y-shaped ray ridges continuing from basals, with secondary radiating ridges horizontally onto adjacent radials. Primanal hexagonal, in radial circlet, supporting 3 anal plates distally, with prominent radial ridges near and normal to margins but not reaching centre of plate, lower central ridge from CD basal most prominent. Anal interray with large number of polygonal plates decreasing in size distally and only roughly in rows. First primibrach hexagonal, with broad low median ray ridge; 2nd primibrach axillary, heptagonal, with median ray ridge in Y-shape to enter 2 arms; 1st secundibrachs hexagonal, in sutural contact up middle of each ray, in contact with 1st intersecundibrach. Secundibrachs fixed in cup but protruding laterally, with 6th axillary, becoming cuneate distally. Arms free distal to about 3rd tertibrach, cuneate uniserial up to 6th tertibrach then biserial and pinnulate, tapering gently, longer than theca; pinnules long, slender, of at least 10 or more pinnulars, attached to each free brachial on both sides of each arm; interprimibrachs numerous, slightly depressed between fixed arms, with single large plate in contact with 2 radials and 1st primibrachs and supporting next row of 2 interbrachials, with more distal rows becoming much smaller and less regularly arranged; intersecundibrachs similar size to interprimibrachs at same height. Tegmen of many small polygonal plates (height of tegmen and anal opening not available). Stem circular, heteromorphic, with nodals higher and of greater diameter than internodals, noditaxis N1.

REMARKS. This species is distinguished within the genus by the distinctive ornament on the proximal theca, the large 1st secundibrach, the low ray ridges not occupying full width of fixed ray plates and the large flat hexagonal 1st interprimibrach. One half ray (Fig. 7A, C) has a normal branching on the 5th secundibrach then another branching on the 2nd tertibrach on the left division: this last branching is not seen anywhere else and is considered aberrant. The axillary tertibrach is cuneate with its long side in the Y of the previous division giving off the abnormal arm which then fills the Y of the previous division with 8-10 quite irregular, mostly cuneate brachials. The reason for this extra arm is not known.

Eudimerocrinus Springer, 1926

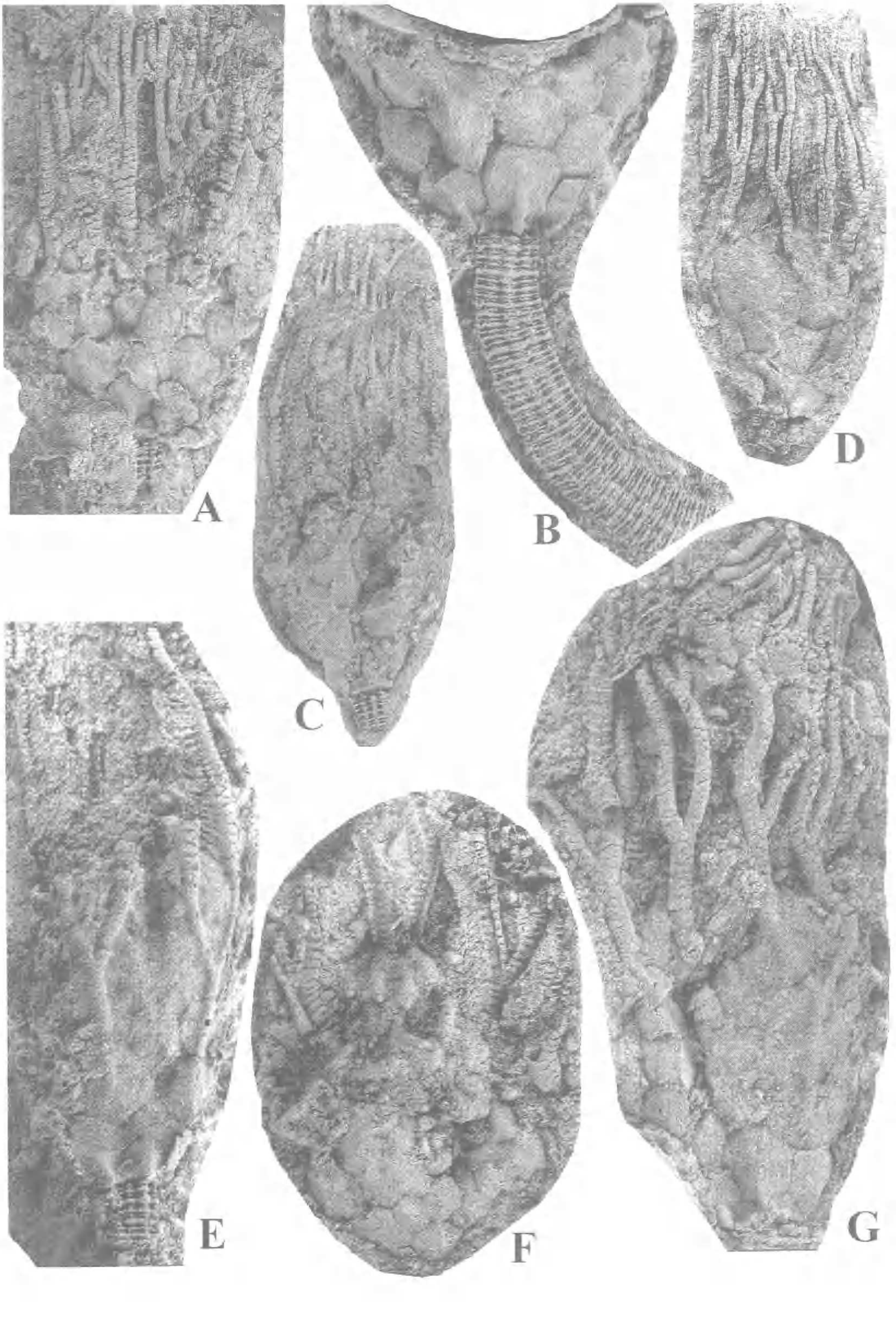
TYPE SPECIES. *Eudimerocrinus multibrachiatus* Springer, 1926 from the Middle Silurian of Tennessee; by monotypy.

DIAGNOSIS. Cup subconical to deep bowl-shaped; basals with strong proximal projections. Arms 40, biserial in free section, with narrow ray ridges. Stem subpentagonal or at least not perfectly round in section.

REMARKS. In erecting this genus Springer (1926) identified the multiple arm branchings as the most significant feature. Ubaghs (1978b) maintained this feature and added a subpentagonal stem. In view of the new Australian species the projections of the basals may be another feature to add to the generic complex.

Witzke & Strimple (1981) placed *Eudimerocrinus* with *Ambicocrinus* Kirk, 1945 and *Griphocrinus* Kirk, 1945 in a group of dimerocrinitids with more than 20 biserial arms. The latter genus is generally distinguished by some if not all its radials being separated by

FIG. 8. *Eudimerocrinus eckardti* sp. nov. all from NMVPL229. A, incomplete specimen NMVP108951, ×1.5. B, partial cup and stem NMVP108963, ×2.5. C,D, part and counterpart of flattened crown NMVP109163a and b, ×1.5. E, holotype crown NMVP109113, ×2. F, partial cup and inner side of arms from opposite side of cup NMVP109090, ×2.5. G, crown NMVP109168, ×2.5.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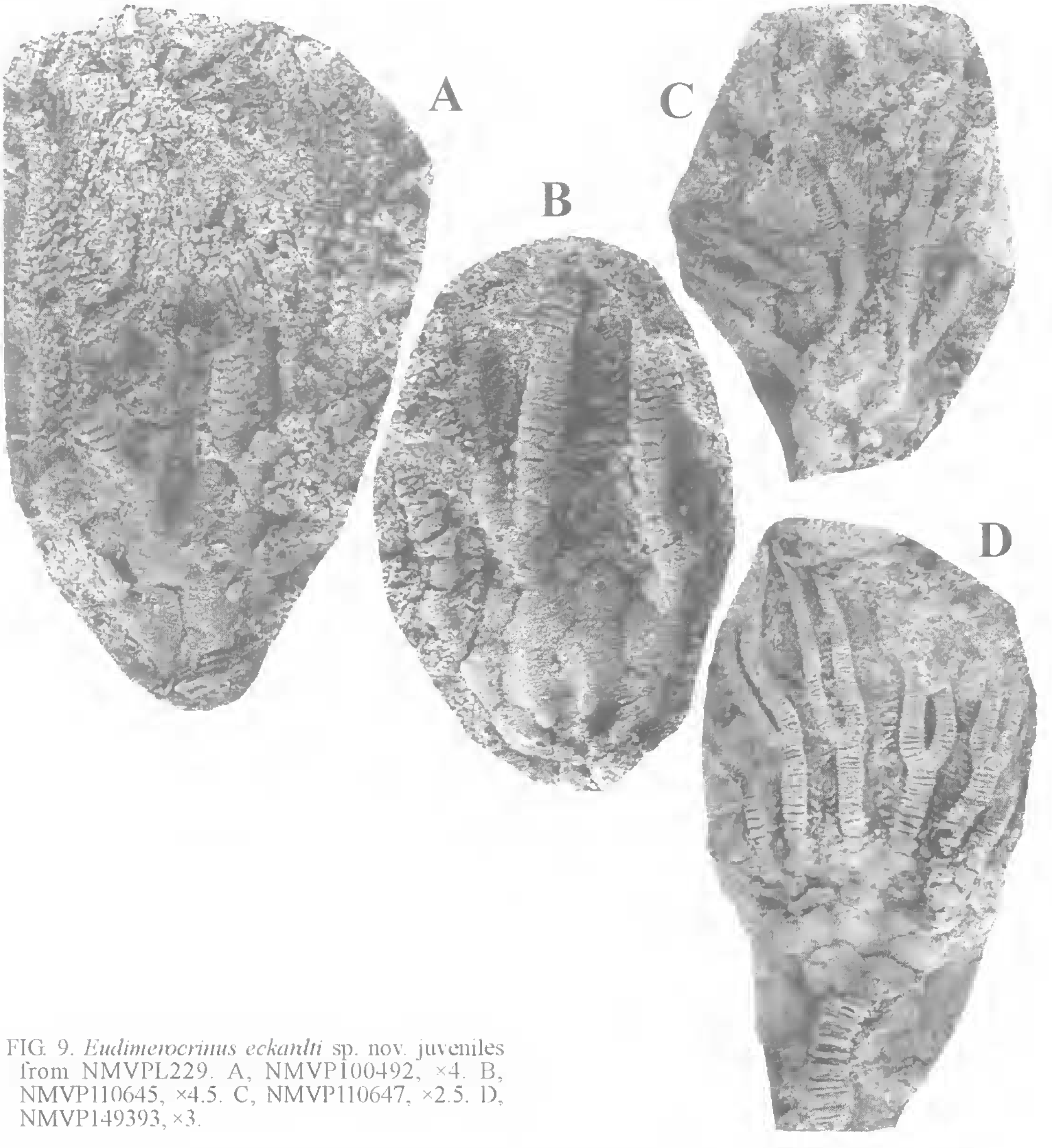
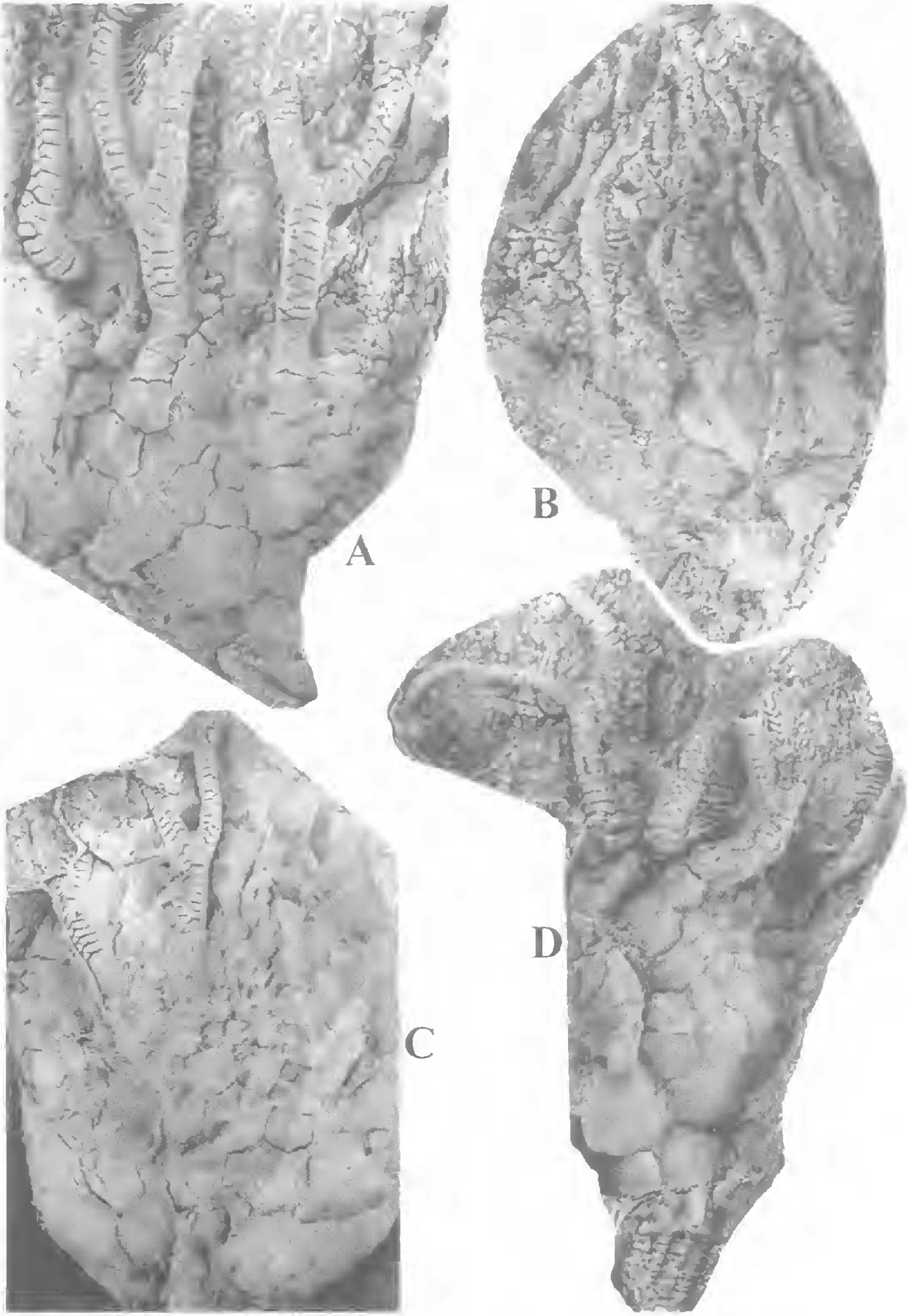


FIG. 9. *Eudimerocrinus eckardti* sp. nov. juveniles from NMVPL229. A, NMVP100492, ×4. B, NMVP110645, ×4.5. C, NMVP110647, ×2.5. D, NMVP149393, ×3.

interbrachials thus placing it intermediate between Rhodocrinitoidea and Dimerocrinitoidea and allowing separation from the other 2 genera; how a species of *Griphocrinus* with all its radials in contact could be distinguished from *Eudimerocrinus* is not clear. On the other hand distinction of *Ambicocrinus* is less certain; it has 40 biserial arms, subpentangular stem and identical cup plating arrangement. Goldring (1923:84) commented on the highly crushed preservation of and difficulty of illustrating the type, *A. arborescens* (Talbot,

FIG. 10. *Eudimerocrinus eckardti* sp. nov. A, partial cup and arms NMVP109767 from NMVPL252, ×2. B, partial cup and arms NMVP108689 from NMVPL229, ×2.5. C, partial cup and arms NMVP109768 from NMVPL252, ×2. D, distorted crown in posterior view NMVP108962 from NMVPL229, ×2.5.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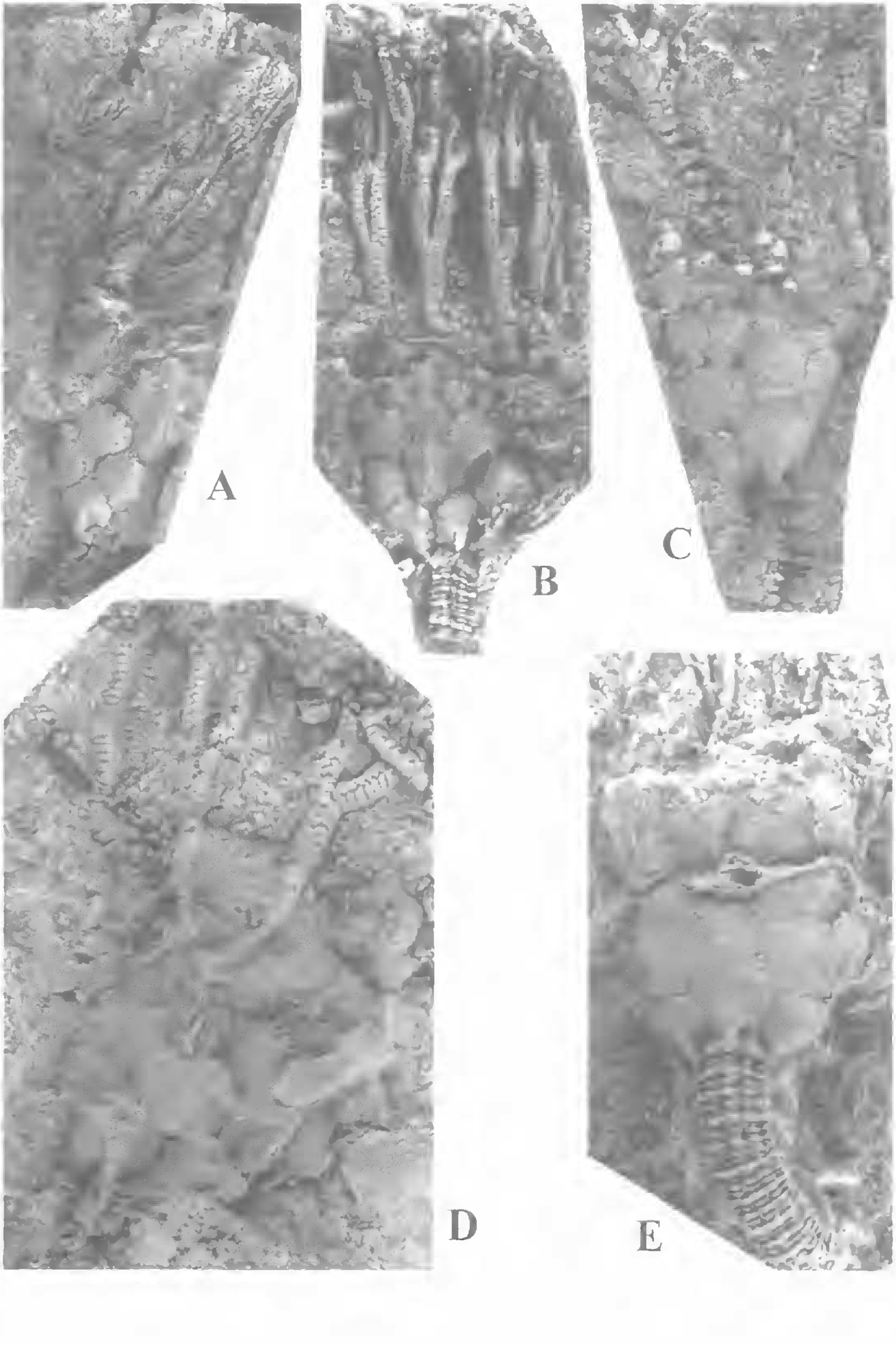
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1905), from the Lower Devonian (Lochkovian) of New York; she also noted its small size and indicated its depiction in her work was a reconstruction by the artist. Only the ray ridges and lack of projecting basals separate *A. arborescens* from *Eudimerocrinus* so given the circumstances noted by Goldring these could well be due to preservation or the artist's licence; I think it highly likely that *Ambicocrinus* is a junior synonym of *Eudimerocrinus* and that *Griphocrinus* may also prove to be synonymous when fully understood.

Eudimerocrinus eckardti sp. nov.
(Figs 8-11)

ETYMOLOGY. For Steve Eckardt who has rendered enormous field assistance and many specimens from his private collection.

MATERIAL. HOLOTYPE: NMVP109113. PARATYPES: NMVP100166, 100492, 108689, 108950, 108951, 108962, 108963, 109090, 109125, 109153, 109163, 109168, 109204, 110645, 110647, 149355, 149393 all from NMVPL229. Other specimens NMVP109221 and 109755 from NMVPL1924 and NMVP109767 and 109768 from NMVPL252.

DIAGNOSIS Basal plates with prominent proximally directed projections near lower margin; median ray ridges variably developed, often prominent; 1st primibrach hexagonal; 2nd primibrach axillary, heptagonal; arms 40, free distal to 4th-6th secundibrach; stem with distinctive decalobate cross section.

DESCRIPTION. Crown up to 55mm long, with cup and arms each about same length; cup up to 10mm long, high bowl-shaped, of large thin plates; infrabasals small, pentagonal, with conspicuous nodes on proximal margin (3 per infrabasal) in line with columns of lobes on stem. Basals 5, 4 hexagonal and CD basal heptagonal, largest plates in cup, with prominent proximally directed projections or spines medially near proximal margin, with spine extending beyond and concealing sutures between adjacent infrabasals, with faint median ray ridges in form of Y (Fig. 8E). Radials heptagonal, with inverted Y-shaped median ray ridge on most specimens, forming contiguous circlet around cup except in CD interray where hexagonal radianal intervenes in circlet; 1st primibrach hexagonal, with median ray ridge running in vertical line; 2nd primibrach axillary, heptagonal, with Y-shaped ray ridge into arms; 1st secundibrachs hexagonal, in sutural contact up middle of each ray, in contact with 1st intersecundibrach; first 6 secundibrachs fixed in cup; free arms biserial and pinnulate distal to 1st free secundibrach, branching approximately at secundibrach 10-11 and tertibrach 11-12, but branching often not at same level even in one ray, of relatively small diameter, tapering gently, approximately as long as theca; adoral groove wide and deep; pinnules long, slender, of at least 4-5 pinnulars, attached to each free brachial on both sides of each arm. Interprimibrachs numerous, not depressed between fixed arms, with single large plate resting on shoulders of 2 adjacent radials, with 2nd row of 2 plates, 3rd row of 3 plates level with top of primary axil, distally becoming much smaller and less regularly arranged with rows having 3-6 plates. Intersecundibrachs with 1st same size as interprimibrachs at same level. Anal interray wider than others, with primanal supporting 3 anals distally, subsequent anal plates without obvious order, decreasing in size to same extent as in interprimibrach series. Tegmen of many small vertically elongate plates, apparently quite long (almost as long as cup); anal opening not seen. Stem decagonal in section, heteromorphic, with noditaxis N3231323, with lobes aligned vertically in 10 columns to give stem appearance of fluted column with differential horizontal layering, no complete stem available.

MORPHOGENY. Small crowns (Fig. 11) have most of the cup occupied by the basals, radials, and first interbrachials, the diameter of the free arms compared to cup diameter is larger than the same ratio in large individuals and free arms are cuneate uniserial. These specimens are assigned to *A. eckardti* mainly because of the basal plate projections and similarity in every other feature available. These differences indicate that through growth the arms change from cuneate uniserial to cuneate biserial and then to rectilinear biserial; the arms do not increase in diameter at the same rate as the cup; and the cup increases in size in more distal parts with addition of interbrachial plates and greater growth there than in lower parts of the cup.

FIG. 11. *Eudimerocrinus eckardti* sp. nov. A, partial specimen with inner side of arms from opposite side of cup NMVP109221 from NMVPL1924, ×2.5. B, crown NMVP149355 from NMVPL229, ×2.5. C, cup and some arms NMVP109755 from NMVPL1924, ×3.5. D, cup and partial arms NMVP109204 from NMVPL229, ×2.5. E, cup and stem NMVP100166 from NMVPL229.

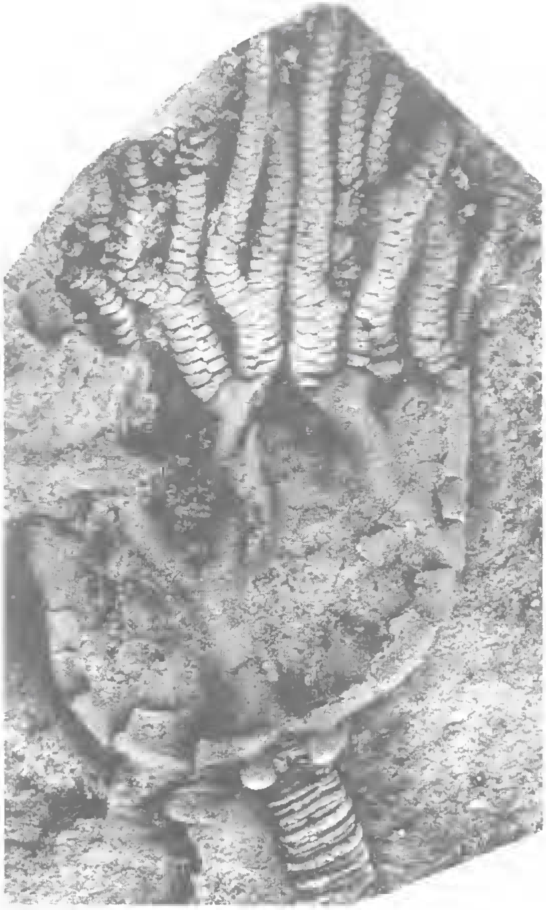


FIG. 12. *Eudimerocrinus gilli* sp. nov., holotype crown NMVP149345 from NMVPL1990, ×3.

REMARKS. This species is distinct within the genus in the detail of its stem, more subtle ray ridges and narrower arms relative to cup plates. It most closely resembles *A. arborescens* (type species of *Ambicocrinus* Kirk, 1945) from the Lower Devonian of New York which is distinguished by lacking the basal plate projections.

Two specimens from NMVPL252 (Fig. 10A, B) are assigned to this species but differ in having a subdued radial ornament on interprimibrachs, radials, primibrachs and secundibrachs and in having the second arm branching farther from the primaxil by about 4-6 brachials. They do have the projections on the basals and so are grouped with the material from NMVPL229 knowing that future material may show them to be part of a separate taxon.

Eudimerocrinus gilli sp. nov.
(Fig. 12)

ETYMOLOGY. For the late Edmund Gill for his geological work around Lilydale.

MATERIAL. HOLOTYPE: NMVP149345 from NMVPL1990.

DIAGNOSIS. Infrabasals barely evident in lateral view; basals with prominent rounded proximal projections; secundibrachs all fixed in cup; arms branching at least 3 times; stem subcircular to subpentagonal.

DESCRIPTION. Crown 32mm long, subcylindrical. Cup deep bowl-shaped, about 12mm long; cup plates thin, smooth except for prominent ray ridges. Infrabasals 5, mostly concealed by stem, upper tips just visible at top of stem between basals. Basals 5, hexagonal, except for pentagonal posterior one, with proximal margin forming part of circular rim to stem attachment, about as long as wide, with prominent well-rounded proximal projection, with median ray ridges emanating from the projections and running onto adjacent radials at right angles to interplate suture. Radials 5, heptagonal, wider than long, with inverted Y-shaped ray ridge. Arms apparently 40, with all primibrachs and secundibrachs fixed in cup, with free arms biserial, tapering distally; 1st primibrach hexagonal, not as wide or as long as radial, with median ray ridge across it; 2nd primibrach axillary, heptagonal, with Y-shaped ray ridge; secundibrachs 6, with median ray ridges, subquadrate or hexagonal; 6th axillary, with 2 round laterally (but not outwardly) declined facets; branching in free arms asymmetrical, with 6th tertibrach axillary in free arms of C and D rays immediately adjacent to CD interray but with next adjacent free arm in C ray having 12th tertibrach axillary and in D ray having 9th tertibrach axillary (branching in A, B and E rays unknown). Interprimibrachs large, numerous, with proximal one supporting 2 plates of about the same size, with size decreasing rapidly distally; CD interray with 1st interprimibrach supporting 3 plates, wider than other interradial areas. First intersecundibrach hexagonal, supporting another 6-8 plates in 3 or 4 rows. Stem circular in section, noditaxis N212, with many low ossicles having wide epifacets (slightly wider in nodals than internodals).

REMARKS. Ubaghs (1978b) distinguished *Eudimerocrinus* from *Dimerocrinites* by its arms

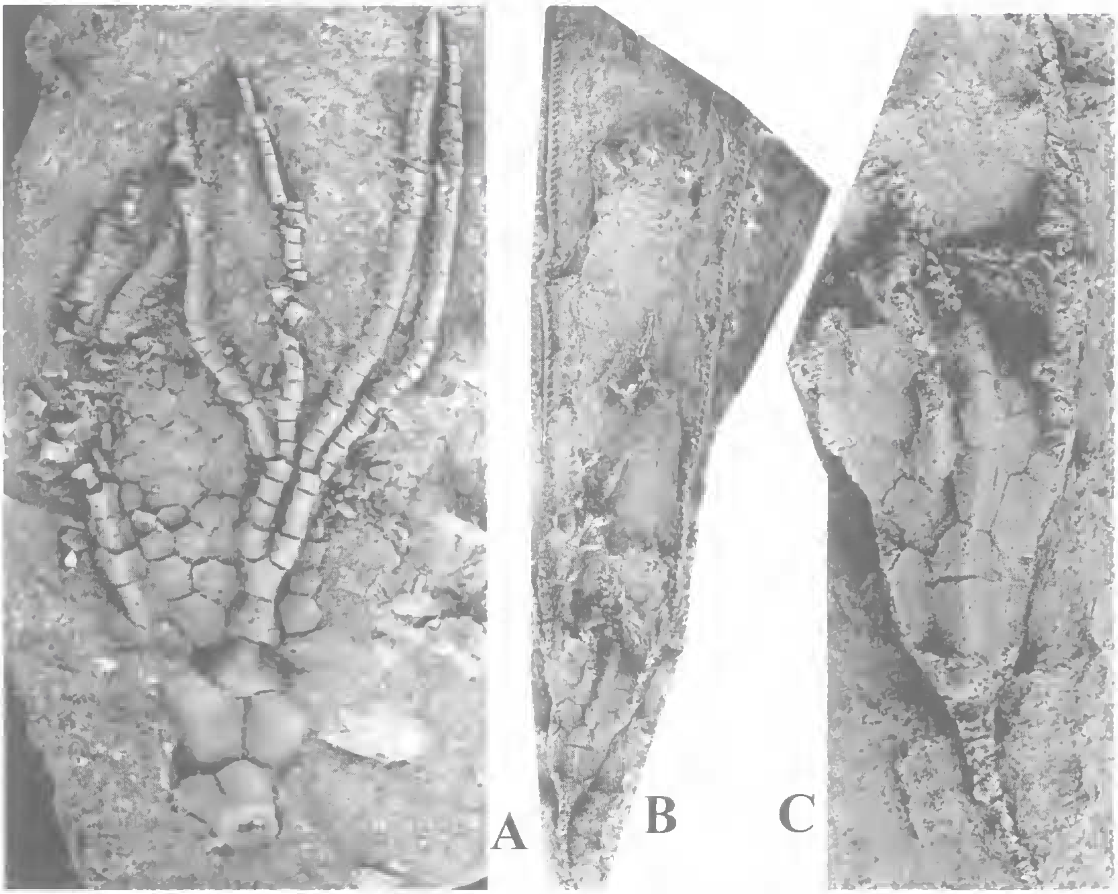


FIG. 13. *Nexocrinus wallanensis* sp. nov. from NMVPL1923. A, lateral view of holotype crown NMVP100116, ×3. B,C, posterior view of crushed crown (and enlargement of cup) NMVP107111, ×2 and ×5, repectively.

dividing several (presumably more than twice) times and its subpentagonal stem; *E. gilli* is thus assigned to *Eudimerocrinus*. It is distinguished from the genotype by the axillary secundibrachs being fixed in the cup, the cup being more bowl-shaped and the arms tapering more rapidly distally.

Nexocrinus Eckert, 1984

TYPE SPECIES. *Nexocrinus delicatulus* Eckert, 1984 from the Llandovery of Ontario; by original designation.

OTHER SPECIES. *Ptychocrinus parvus* Hall, 1872 from the Upper Ordovician of North America; *Nexocrinus wallanensis* sp. nov. Ludlow of Victoria; *Dimerocrinites occidentalis* (Hall, 1863) from the Middle Silurian Waldron Shale of USA; *Nexocrinus* sp. Lochkovian of Victoria (herein); *Ptychocrinus adamensis* Ausich & Dravage, 1988 from the Llandovery of Ohio.

DIAGNOSIS. Cup conical; CD interray slightly wider than others; ray ridges prominent, may be subdued on proximal cup plates; infrabasals concealed by stem to long in lateral view. Posterior basal hexagonal, supporting primanal that separates C and D radials; arms 20, 4 per ray, uniserial, pinnulate, much longer than cup.

REMARKS. Brower (1973) dealt in detail with *Ptychocrinus* noting that the 3 Upper Ordovician species assigned are probably generically distinct. Eckert (1984) agreed that the genus was in need of revision and suggested that *P. parvus* should be removed because it had 20 arms unlike any other species included. He noted the similarity of his new genus to *P. parvus* but separated them on the number of fixed secundibrachs, width of the CD interray, distinctness of the anal ridge and plating of the posterior interray. Of these features the new Victorian species shares with *N. delicatulus* the 4 fixed secundibrachs, the distinct anal ridge and the plating arrangement of the posterior interray. The only major distinction of the Victorian species is that its infrabasals are fully in view laterally and the ray ridges become less distinct proximally. I consider these to be interspecific differences and not of generic significance in the same way that the differences between *P. parvus* and *N. delicatulus* noted by Eckert (1984) distinguish those species within one genus. *Ptychocrinus adamsensis* Ausich & Dravage (1988) from the Llandovery of Ohio could be assigned to *Eucrinus* since it has 20 biserial (partially) arms. However, Ausich & Dravage (1988) made a good case for assigning it to the previously exclusively uniserial *Ptychocrinus*; they did not consider comparison with *Nexocrinus* which is a ptychocrinid genus with 20 uniserial arms distinguished by axillary 4th secundibrachs and some features of the posterior interradius. Since the posterior interradius of *adamsensis* is not available its features cannot be compared. However, the second division of the arms is at the 4th or 5th secundibrachs in *adamsensis* and I consider this species should be assigned to *Nexocrinus*. Ausich & Dravage (1988) argument that a species with uniserial proximal arms becoming biserial distally can belong to an essentially uniserial genus commands re-assessment of species with such arms. A single specimen from the Lower Devonian of Victoria with such arms, though they become biserial a little more proximally than in *adamsensis* and with 6th secundibrachs axillary, is assigned to this genus herein. That specimen is comparable to *Dimerocrinites occidentalis* (Hall, 1863) from the Silurian Waldron Shale of central USA on features of the cup but since arms are unknown for the latter species its assignment is equivocal.

Nexocrinus wallanensis sp.nov.
(Fig. 13)

ETYMOLOGY. From near the town of Wallen.

MATERIAL. HOLOTYPE: NMVP100116 and paratype NMVP107111 from NMVPL1923.

DIAGNOSIS Infrabasals long in lateral view; ray ridges prominent above the radials, becoming less distinct proximally. Primibrach 2 and secundibrach 4 axillary; arms fixed in cup up to about tertibrach 4 or 5. Arms 20, 4 per ray, uniserial, with primibrach 2 and secundibrach 4 axillary. Interrays with large number of polygonal plates (1 in first row followed distally by rows of 2, 3, 4 then irregular). Posterior interray with large basal longer than other basals; primanal directly distal, hexagonal, supporting 3 plates distally; prominent anal ridge medially on central column of vertically elongate hexagonal anal plates. Surface of plates smooth.

DESCRIPTION. Crown more than 60mm long, flaring distally. Cup high conical, with most of length in tegmen, with some tertibrachs fixed in cup. Infrabasals longer than radials, pentagonal, with highly obtuse angle distally. Basals hexagonal, large, largest plates in cup, with very faint broad ridges in X-shape crossing proximal and distal sides normal to margins. Radials heptagonal, in contact with adjacent radials except presumably in CD interray, with subtle ridges from basals continuing to meet medially near upper margin and continue as more prominent single ridge into brachials. First primibrach hexagonal, more convex in arm section distally; 2nd primibrach axillary, heptagonal, in contact with 2nd and 3rd rows of interbrachial plates; 4th secundibrach axillary; all secundibrachs and 2-3 tertibrachs fixed in cup. Free arms 4 per ray, with short fine pinnules, longer than cup, uniserial, with length of brachials decreasing gradually distally; pinnules one per brachial, alternating from side to side along arm. Interprimibrachs numerous, in regular rows of 1, 2, 3, 4, with 1st resting on shoulders of radials, with distally large number of irregular polygonal plates forming large but presumably not very competent tegmen; intersecundibrachs and intertertibrachs not clearly evident. Anal interray with basal longer than other basals, with distinct median ridge from infrabasal to tegmen; primanal and subsequent median plates long, hexagonal, with greatest width above midlength; other anal plates large, polygonal. Stem subcircular to subpentagonal in section, with pentagonal lumen.

REMARKS. This species is assigned to *Nexocrinus* on cup shape, ray ridges, shape of plates in the median anal column, 20 uniserial arms and depressed interprimibrachs. It is distinguished within the genus by the length of the infrabasals in lateral view. This species may ultimately prove to be generically distinct but in the present state of knowledge this is the most likely placement.

Nexocrinus sp.
(Fig. 14)

MATERIAL. NMVP149343 from NMVPL252.

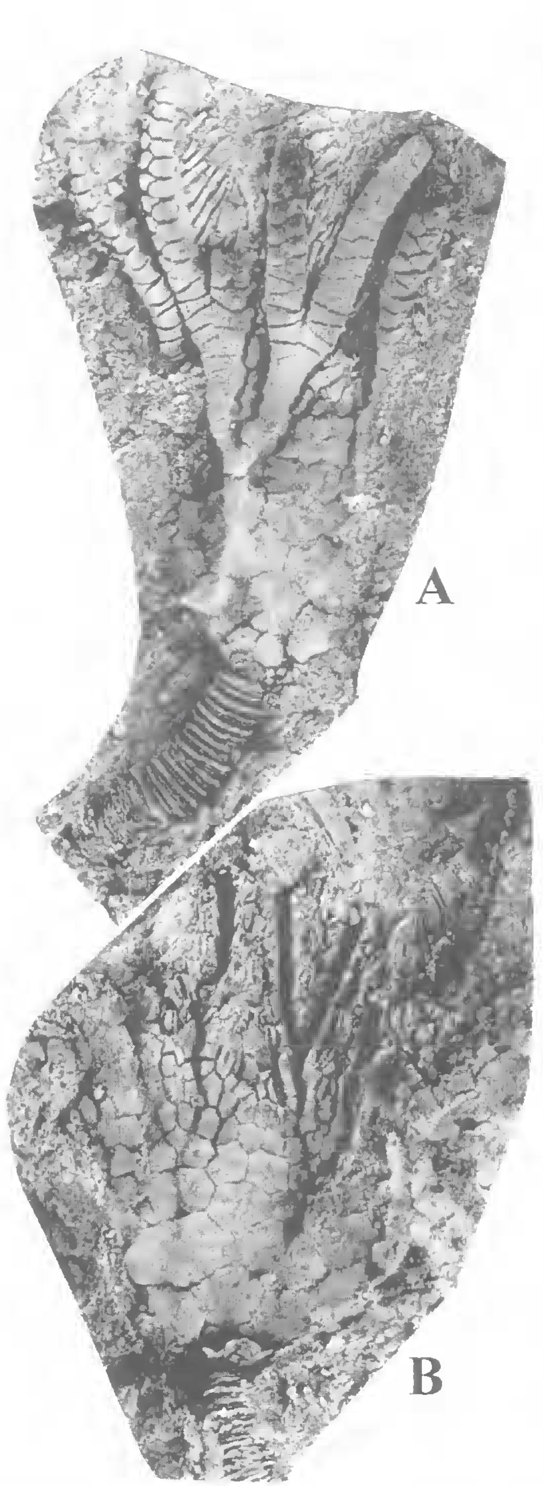


FIG. 14. *Nexocrinus* sp. incomplete crown in lateral view external (A) and internal (B) NMVP149343 from NMVPL252, ×4.

DESCRIPTION. Cup high conical, of thin plates, with median ray ridges well-developed, with radial ornament on interbrachial areas. Infrabasals 5, small, visible in lateral view, with ray ridges from adjacent basals meeting medially on the lower margin. Basals 5, hexagonal (posterior one presumably heptagonal and supporting 3 anal plates distally), smaller than radials, with cross of broad ray ridges from adjacent radials and infrabasals. Radials 5, heptagonal, much wider than long, with inverted Y-shaped ridges forking at midpoint of plate, with much thinner and lower ridges radiating from the midpoint to the middle of the other 4 sides. First primibrach hexagonal, wider than long, crossed vertically by prominent ray ridge, with faint lateral ridges from centre to sutures with interbrachials. Second primibrach pentagonal, axillary, with ray ridges occupying most of plate and dividing into both rami, with lateral marginal flange and upper tip depressed to interray areas. First secundibrachs and tertibrachs in contact laterally. Secundibrachs uniserial, cuneate, fixed, 6th axillary, with number of small long narrow intersecundibrachs up to level of 1st tertibrach. Tertibrachs cuneate for proximal 3 or 4 then biserial, with long pinnules on each brachial on each side of arm in biserial part (full length of arms not available).

Interprimibrachs numerous, 1 in first row more distal rows with 2, 3, 4, then becoming more elongate and less regular, with fine radial ornament. Anal interray unknown. Internal mould of cup with a groove in cup plates matching the position of the ray ridges, beginning on the radials, becoming deeper and narrower upwards onto the arms, suggesting that similar though shallower and less distinct grooves branched from the 3rd secundibrach out and up across lateral interprimibrachs. Stem circular in section, noditaxis N1, of very low ossicles of uniform length but with epifacet of nodals of greater diameter than that of internodals.

REMARKS. This specimen resembles *Dimerocrinites occidentalis* (Hall, 1863) from the Silurian Waldron Shale of Indiana with which it shares the infrabasals well exposed in lateral view, narrow ray ridges, fine radial ornament on interbrachials and fine longitudinal ornament on the ray ridges. However, it may be distinguished by its larger diameter stem (relative to thecal diameter), the ray ridges on basals in an X rather than a Y as in *occidentalis* and its 20 arms as opposed to the 10 surmised in *occidentalis*. No illustrated specimen of *D. occidentalis* is complete in the arms distal to about the 2nd

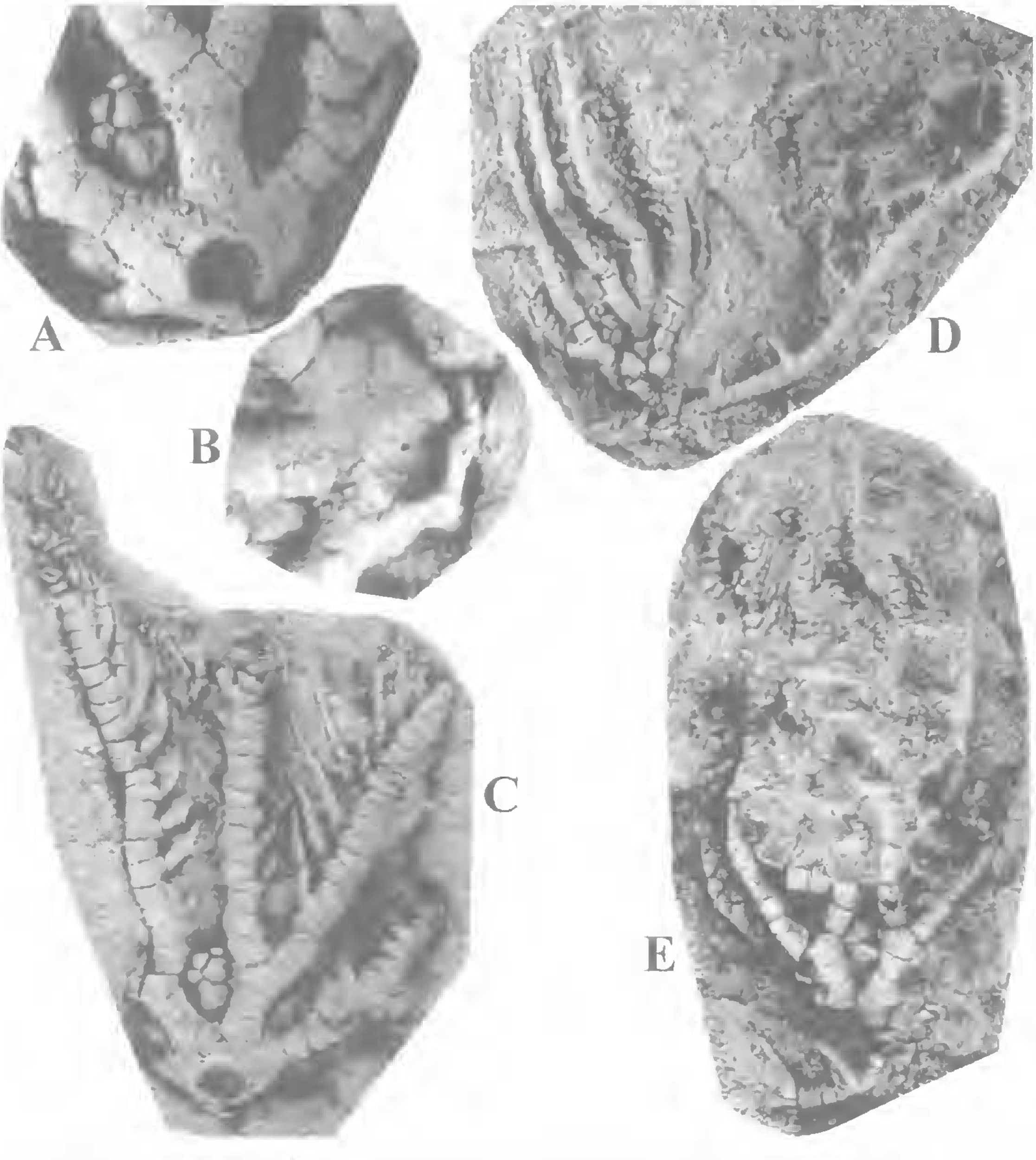


FIG. 15. *Duncanicrinus calvariolus* gen. et sp. nov. A-C, NMVP110649 from the rubbish tip on Watson's Road, Pheasant Creek, Kinglake. A, E ray enlarged view of cup, ×10. B, enlarged basal view of cup with posterior basal at 12 o'clock, ×10. C, crown in E ray view with distal arms incomplete, ×5. D,E, part and counterpart of slightly disarticulated NMVP108647 from NMVPL252, ×4.

secundibrach. This Australian specimen illustrates that the second division of the arms is on the 5th or 6th secundibrach so it is quite possible that the arms of *D. occidentalis* may have divided a second time to produce 20 arms. Until the arms of this North American species are known the comparison must remain incomplete but I suggest it is more likely that *occidentalis* belongs to *Vexocrinus* than to *Dimerocrinites* or *Eucrinus*.

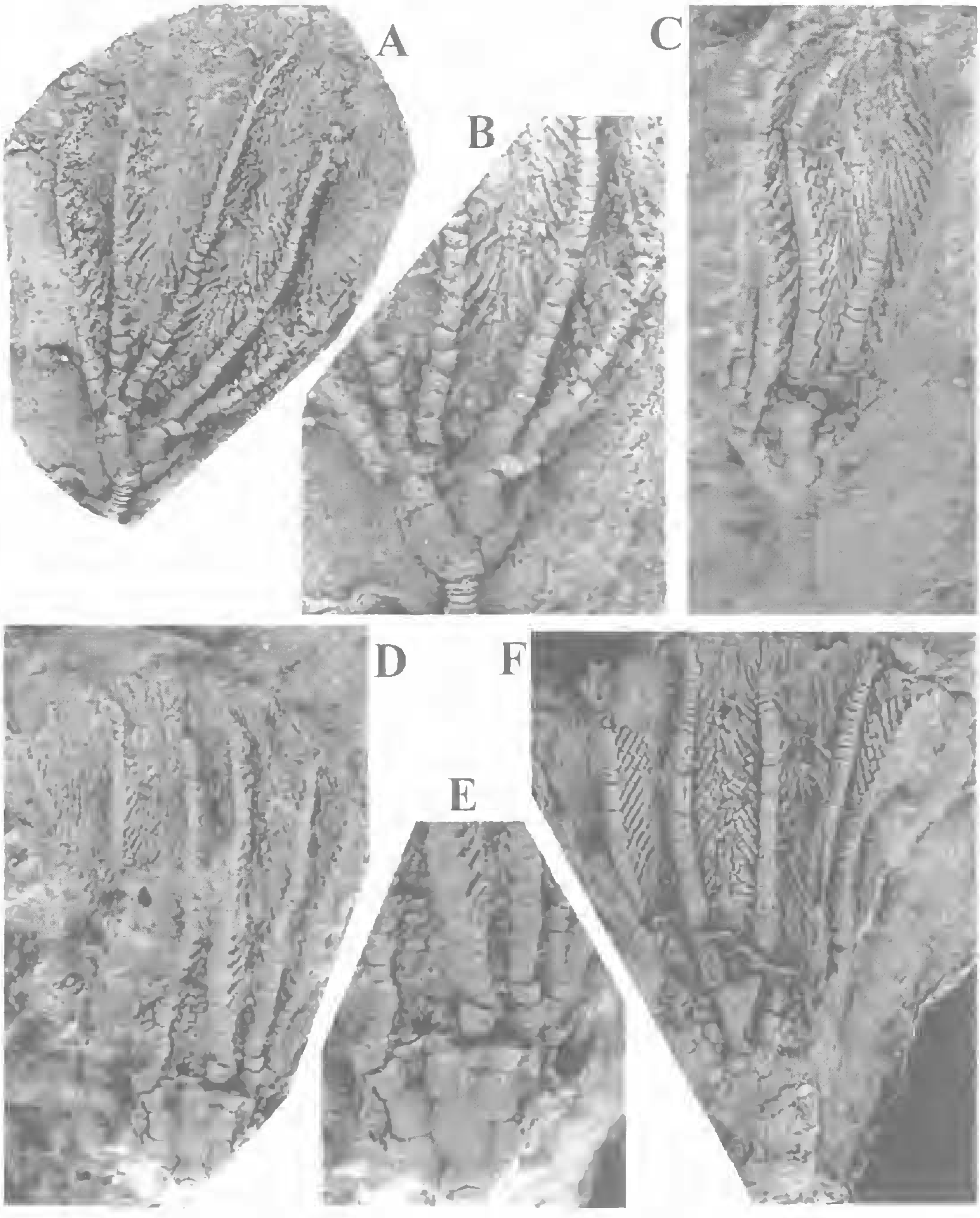


FIG. 16. *Duncanicrinus calvariolus* gen. et sp. nov., all crowns from NMVPL252. A,B, NMVP108640, ×4 and ×6, respectively. C, NMVP108634, ×5. D,E, NMVP108617, ×6. F, NMVP108633, ×2.5.

Duncanicrinus gen. nov.

TYPE SPECIES. *Duncanicrinus calvariolus* sp. nov.

ETYMOLOGY. For Peter Duncan of the Whittlesea district, a benefactor of Victorian palaeontology.

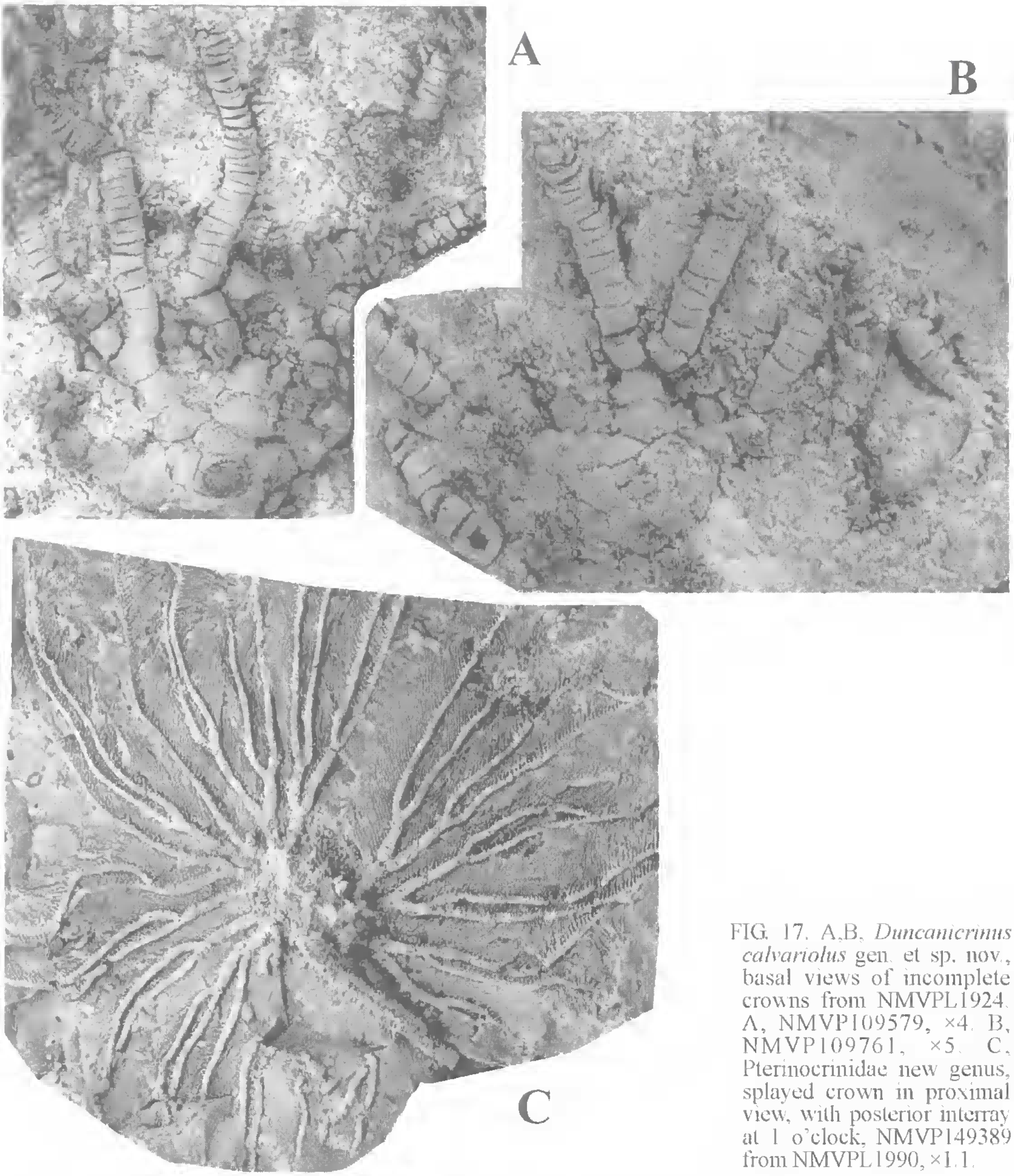


FIG. 17. A,B, *Duncanicrinus calvariolus* gen. et sp. nov., basal views of incomplete crowns from NMVPL1924. A, NMVP109579, ×4. B, NMVP109761, ×5. C, Pterinocrinidae new genus, splayed crown in proximal view, with posterior interray at 1 o'clock, NMVP149389 from NMVPL1990, ×1.1.

OTHER SPECIES. *Ptychocrinus fimbriatus* (Shumard, 1855) from the Ordovician of USA; *Ptychocrinus longibrachialis* Brower, 1975 from the Silurian of Scotland.

DIAGNOSIS. Cup conical, of smooth or tuberculate plates, with or without ray ridges. Infrabasals 5, pentagonal, concealed by stem attachment or partially visible in lateral view. Basals 5, hexagonal; posterior basal longer than others, reaching more than halfway up radials. Radials in lateral contact except in posterior interray. Interprimibrachs few, beginning with one resting on radials. Tegmen of small polygonal plates. Arms 10, uniserial, of cuneate brachials, with long pinnules on prominent facets alternating along arm. Stem circular, noditaxis N3231323, some with cirral spines at noditaxis base.

REMARKS. Brower (1973) noted that within the Dimerocrinitidae the 3 Ordovician species of *Ptychocrinus* could be regarded as belonging to separate genera. In discussing phylogeny he suggested that the forms with 10 arms may belong to one lineage and could have given rise to the 10 armed *Dimerocrinites*. Accepting Brower's (1973) phylogeny the Victorian species is placed with *Ptychocrinus fimbriatus* in a genus characterised by 10 uniserial arms that was foreshadowed by Jell (in Jell & Holloway, 1983) in discussion of the holotype, then the only known specimen. *Macarocrinus* Jaekel, 1895 is a related genus but its type, *M. springeri* Jaekel, 1895 has 15 arms and is considered generically separate. Species of *Macarocrinus* with 10 arms should probably be transferred to *Duncanicrinus* but detailed study of those species is outside the scope of this paper.

Duncanicrinus calvariolus sp. nov.
(Figs 15-17)

Dimerocrinitidae gen. et sp. nov. Jell in Jell & Holloway, 1983:12, figs 7C-E, 8

ETYMOLOGY. Latin *calvariola*, small cup.

MATERIAL. HOLOTYPE: NMVP74246 from the floor of Winneke Reservoir, Christmas Hills, E of Melbourne described and figured by Jell (in Jell & Holloway, 1983:12, figs 7C-E, 8) as Dimerocrinitidae gen. et sp. nov. PARATYPES: NMVP110649 from the rubbish tip on Watson's Road, Pheasant Creek, Kinglake and NMVP108617, 108633, 108634, 108640, 108647 all from NMVPL252. Other material NMVP109579, 109761 and 109763 from NMVPL1924.

DIAGNOSIS. Cup very small, of smooth plates, without ray ridges. Infrabasals may or may not be visible in lateral view. Interprimibrachs few, maximum of 6-8 per interray. Arms free distal to primaxil. Stem cirriferous.

DESCRIPTION. Crown up to 30mm long, strongly flared in proximal part then subcylindrical, with arms more than 5 times as long as cup. Cup very small (about 2mm across and 1.5mm long), conical, of smooth thin plates, with shallow sharply rimmed stem facet. Infrabasals 5, completely concealed by stem (Fig. 15B), just visible laterally as wide low triangle (Jell & Holloway, 1983, fig. 7C) or fully visible and pentagonal (Fig. 15D). Basals 5, usually hexagonal, maybe pentagonal with proximal margin slightly curved and forming sharp margin to basal concavity, occupying up to 60% of cup length, with acute distal tip at point where radials begin to descend into interradial depressions; posterior basal heptagonal, supporting primanal above horizontal suture, remainder of anal sac uncertain but apparently with median anitaxis of hexagonal plates. Radials 5, heptagonal, contacting each other laterally through lateral flanges in interradial depressions; radial facet peneplenary (c.0.8 of radial width), horizontal, subcircular in section. Each primibrach with lateral flanges in interradial depression in line with those on radials. Arms 10, with axillary 2nd primibrach, free distal to primaxil, of cuneate secundibrachs, with long pinnules alternating side to side along each arm; each pinnule of 8 pinnulars. Interprimibrachs convex, in regular rows 1, 2, 3 distally. Stem circular in section, noditaxis N3231323, with nodals each bearing stout cirri.

REMARKS. The specimen from Winneke Reservoir is now fully interpretable with discovery of the several specimens from different localities all just to the NE of Melbourne. This species is distinguished from *D. fimbriatus* by its smaller cup, fewer smaller interprimibrachs and cirriferous stem. There is some variation within the species in the amount of the infrabasals visible laterally, in the interbrachials and in the shape of the brachials but none of this variation can be considered interspecific. The discussion of the holotype provided by Jell (in Jell & Holloway, 1983) indicated close relationship to *Ptychocrinus* and this is confirmed here with closest relationship to *Ptychocrinus fimbriatus* now assigned to *Duncanicrinus*.

Family PTERINOCRINIDAE McIntosh, 1987

Pterinocrinid gen. nov.
(Fig. 17C)

MATERIAL. NMVP149389 from NMVPL1990.

DESCRIPTION. Crown splayed on bedding plane, approximately 50mm in diameter. Cup low bowl-shaped (probably more conical originally and now shortened by compaction), with plate margins not discernible; ornament of prominent ray ridges. Infrabasals not discernible. Basals presumably 5, not discernible except posterior one intervening between C and D radials; posterior basal 5-sided, with strong central boss and 5 radiating ridges to centre of each side. Radials 5, 5-sided, with 2 ray ridges from centre of 2 proximal sides meeting at centre of plate then running to centre of distal side; C and D radials with extra ridges to anal X. Posterior interray wider than others; anal X large, resting on basal, separating C and D radials, supporting 3 anal plates, with ray ridges running vertically and 2 running diagonally from adjacent radials; distal anal plates not clearly defined but with strong tubercles or short spines. Arms 40 (if branching is regular; E ray appears to have one branch missing the 3rd division and another with a 4th division - maintaining the 8 branches for the ray but irregularly; C and D rays branching regularly); primibrachs 2, with 1st hexagonal, with 2nd pentagonal and axillary; secundibrachs not readily countable due to preservation but approximately 5 or 6, 3 or 4 fixed in cup; free brachials with raised proximal and distal marginal rims leaving a distinct groove at midlength, each with 2 long slender pinnules, one on each side of arm; pinnules with more than 6 pinnulars each. Stem pentagonal in section, with angles of stem aligned with ray ridges bisecting proximal margin of each basal, heteromorphic, with lateral extremities of each columnal at 5 stem angles appearing to be curved distally (possibly due to preservation).

REMARKS. Although infrabasals are not clear there are many dimerocrinitoids in which they are concealed by the stem and the plate arrangement is not characteristic of monocyclic camerates. I therefore, infer concealed infrabasals. The compound biserial brachials assign the taxon to the Pterinocrinidae within this superfamily and the prominent ray ridges separate it from all other members of the family except *Apurocrinus* McIntosh (1981) from which it is distinguished by its different branching pattern. McIntosh (1987) described cornice-shaped rims along distal lips of free brachials in the other South American Devonian pterinocrinid *Bogotacrinus scheibei*; its brachials are thus very similar to those of the Victorian taxon where a similar rim also occurs on the proximal lip. *Bogotacrinus* is also comparable in having a pentagonal stem in the same relationship to the basal circlet. However, *Bogotacrinus* lacks strong ray ridges and has a different arm branching pattern. Relatively poor preservation of the single specimen available precludes application of a formal name so I retain the new taxon in open nomenclature. Although McIntosh (1979) described the columnal in the stem facet as round, his figure (McIntosh, 1979, fig. 5.1) clearly shows it to be subpentagonal with each angle at the centre of the proximal edge of a basal.

Order MONOBATHRIDA
Moore & Laudon, 1943
Suborder COMPSOCRININA Ubaghs, 1978
Superfamily HEXACRINITOIDEA
Wachsmuth & Springer, 1885
Family HEXACRINITIDAE
Wachsmuth & Springer, 1885

Hexacrinites Austin & Austin, 1843

TYPE SPECIES. *Platycrinites interscapularis* Phillips, 1841 from the Middle Devonian of England; by monotypy.

REMARKS. This genus is widespread throughout the Devonian of Australia (Philip, 1961 - L. Dev.; Jell et al., 1988 - M. Dev.) This is the first species with upper arms preserved and with unweathered plate surfaces.

Hexacrinites chirnsidensis sp. nov.
(Fig. 18)

ETYMOLOGY. From Chirnside Park, an outer suburb of Melbourne, near Lilydale.

MATERIAL. HOLOTYPE: NMVP107097. PARATYPES: NMVP107095, 107096, 107098, 107100, 110644 all from NMVPL1922.

DIAGNOSIS. Low but distinct median ray ridges on all cup plates except primanal; 1st primibrach and 4th secundibrach axillary; 4 arms per ray. Stem circular; columnals almost as high as diameter, with protruding flange near midlength.

DESCRIPTION. Crown up to 25mm long, conical proximally, less flared distally. Cup high conical, of unornamented plates except for ray ridges. Basals 3, equal, symmetrically beneath A, C and D radials, with a median ray ridge centrally on A basal leading onto A radial, with 2 other ray ridges from A basal continuing onto B and E radials, with 2 median ray ridges on each of other 2 basals continuing onto B, C and D, E radials, respectively (Fig. 18A), with distinct rim around stem attachment giving rise to ray ridges. Radials 5, up to twice as long as wide, each with distally decreasing median ray ridge; radial facet about 1/2 radial width, declivate, semicircular to horseshoe-shaped on outer but only weakly convex on interior. Primanal same size as radials, smooth, without ray ridge or facet. Arms 20, 4 per ray, uniserial, with deep groove on inner side of each. First primibrach axillary, pentagonal; secundibrachs 4 per arm, 4th axillary, subquadrate in lateral view, almost circular in section except for

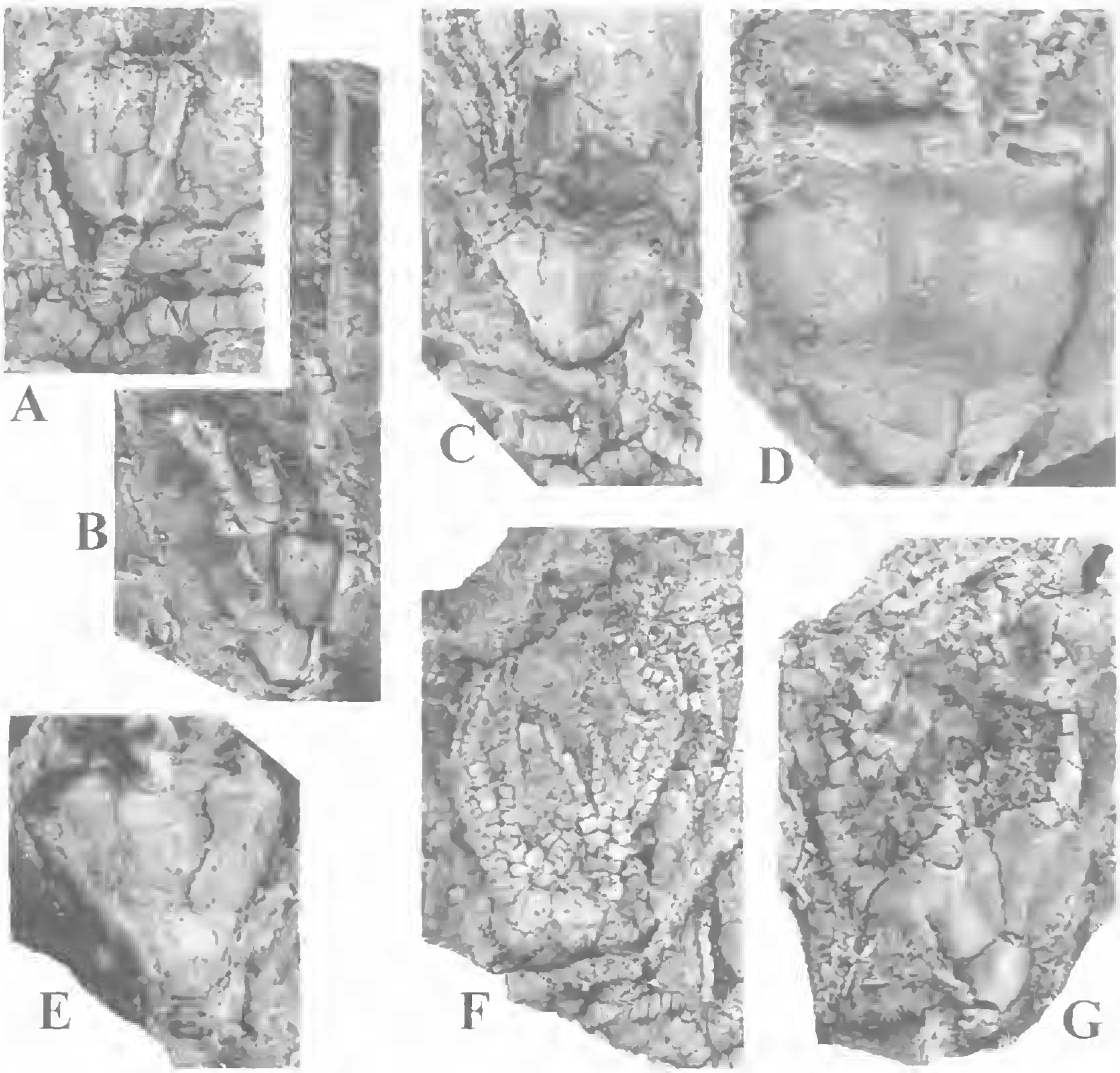


FIG. 18. *Hexacrinites chirnsidensis* sp. nov., all incomplete crowns from NMVPL1922. A,C, part and counterpart of holotype NMVP107097, ×3.5 and ×4, respectively. B,G, part and counterpart of NMVP107098, ×4. D, internal mould (not a latex cast) of NMVP107095, ×5. E, NMVP107100, ×6. F, NMVP107096, ×2.5.

groove on inner side, apparently not pinnulate; tertibrachs becoming cuneate distally, with large well-developed facet for attachment of pinnules; pinnules one per brachial, alternating from side to side up each arm (distal extent of arms not available). Single large plate of tegmen adjoining radials between radial facets. Stem circular in section, with strongly crenulate sutures between columnals throughout, heteromorphic proximally; proximal section of short columnals with lateral flange at midlength, with flange slightly wider on nodals; distal section of uniform columnals, long (as long as 4 proximal columnals), with lateral midlength flange occupying only small part of length of columnal.

REMARKS. Most species of *Hexacrinites* have some obvious and distinctive ornament on the basal and radial plates; a few are smooth (some illustrated specimens may be smooth through postmortem weathering) but none of the smooth species have the subtle ray ridges of *H. chirnsidensis*. A similar species is *Arthroacantha vega* Prokop, 1982 which shares the very long basals, subtle median ridge ('considerably convex, especially in their middle parts' Prokop, 1982) on radials but not on radianal and horizontal depression of radial plates just proximal to distal margin. It is distinguished by the tuberculate ornament which is the only feature that could be used to assign the Czech species to *Arthroacantha*. However, numerous species of *Hexacrinites* have tuberculate ornament and I suggest that *A. vega* probably belongs to *Hexacrinites* closely allied to *H. chirnsidensis*. Similar also is the specimen of *Hexacrinites* described by Philip (1961) which is available as an interior mould having a distinct median convexity, a horizontal groove just proximal to the distal margin and long conical shape all the same as in *H. chirnsidensis*; it is quite possible that Philip's specimen and the Chirnside Park material are conspecific.

Oehlerticrinus LeMenn, 1975

TYPE SPECIES. *Oehlerticrinus sefflouensis* LeMenn, 1975 from the Lower Devonian of France; by original designation.

REMARKS. LeMenn (1975) erected this genus for 5 species for hexacrinitids with strongly and distinctively ornamented cup plates, with 2 primibrachs, with organised interbrachial plating, with compound brachials and with a cirriferous stem. The last 2 features are evident in only one species each and their occurrence in the other species are inferred. Although the 2 species added herein have uniserial arms and non-cirriferous stems they are assigned to this genus because 1) basic cup plate ornament is evident though less striking; 2) there are 2 primibrachs; 3) the primanal supports 3 plates; and 4) a single large interbrachial rests on adjacent radials and is surrounded distally by small polygonal plates. Of other hexacrinitids with 2 primibrachs *Arthroacantha* Williams, 1883 from the Devonian of Europe and North America has spines articulated on tubercles on the cup and biserial arms that branch 3 times and lacks a linear cup plate ornament, *Platyhexacrinus* Schmidt, 1913 from the Devonian of Europe and Siberia is similarly distinguished except that it lacks the cup spines and has a very inflated tegmen, while *Prohexacrinus* Yakovlev, 1946 from the Silurian of the Urals also has a subglobose cup and almost equidimensional radials. When the stem and arms are known for all species the variation here inferred may suggest further subdivision but at present assignment to *Oehlerticrinus* is considered most likely.

Oehlerticrinus lemenni sp. nov.
(Figs 19, 20)

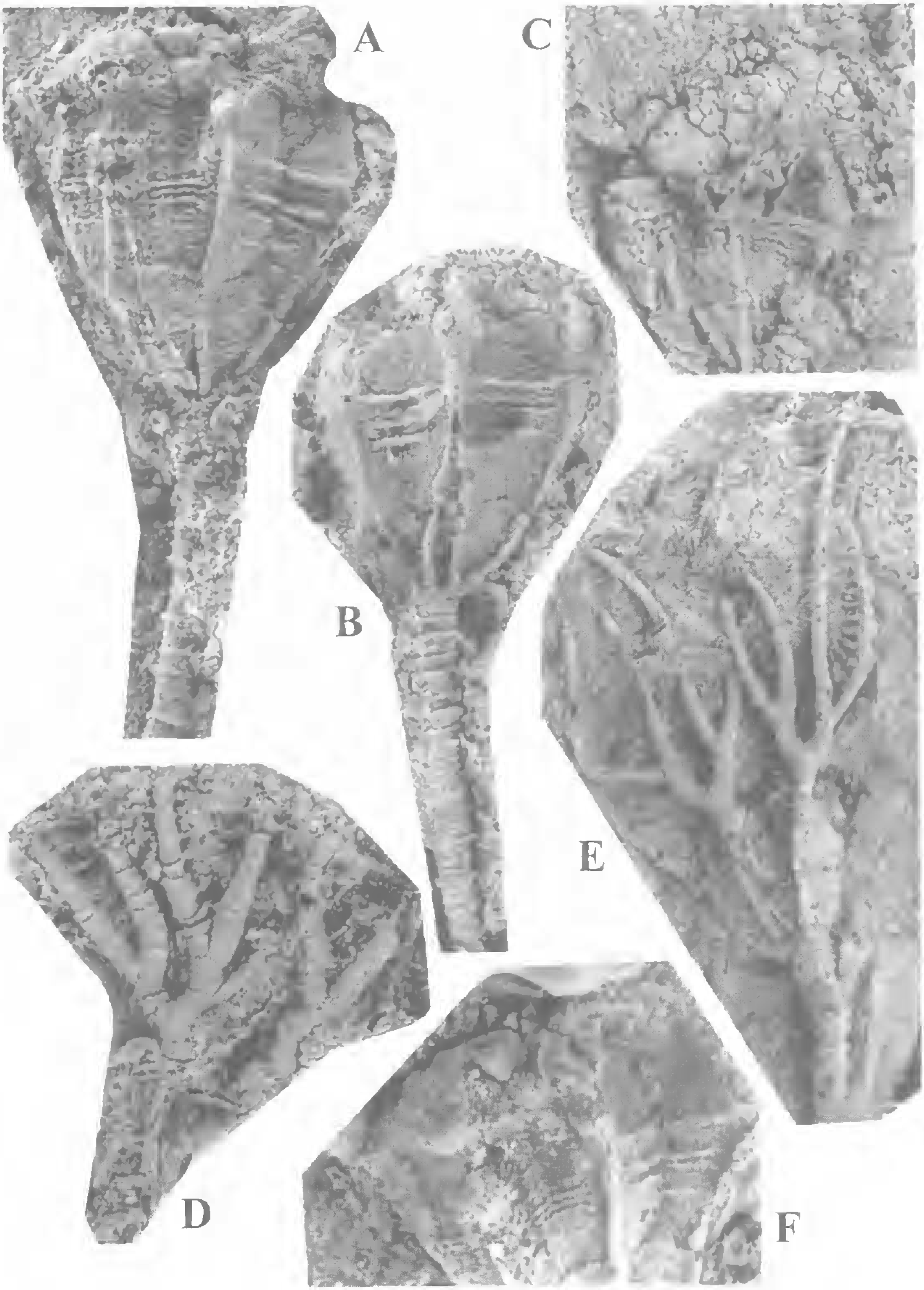
ETYMOLOGY. For Jean Le Menn, the author of the genus.

MATERIAL. HOLOTYPE: NMVP109213. PARATYPES: NMVP109098, 109116, 109164, 109166, all from NMVPL229, NMVP108672, 108679 and 108682 from NMVPL252.

DIAGNOSIS. Cup high conical. Ornament of strong narrow ray ridges single on A, C, and D radials, double on B and E radials and primanal, with slightly less prominent sharp horizontal ridges around the cup at height of radial facet and just proximal to it, with background ornament of fine tubercles over entire cup. Tegmen with 5 large subtriangular interambulacrals surrounded orally by small irregular ambulacrals. Arms 20, rectilinear uniserial. Stem circular in section, heteromorphic with strongly crenulate intercolumnal suture, with columnals becoming longer distally.

DESCRIPTION. Crown up to 48mm long, with arms flaring distally and more than twice as long as cup. Cup high conical, consisting of basals, radials and primanal. Basals 3, equal, forming hexagonal circlet, symmetrically beneath A, C and D radials, occupying about 30% of cup length, each with 3 ridges radiating from distinct rim around stem attachment and crossing each of 3 distal edges. Radials 5, up to twice as long as wide, about 70% of cup length, with narrow sharp ridges continuing from basals, with similarly narrow and sharp horizontal ridges running around the cup at height of facet and just proximal to it, horizontal ridges fading out on approach to vertical ridges, with background of fine tubercles over entire cup; A, C and D radials with single median vertical ridge; B and E radials and primanal each with 2 ridges quite close together and converging on base of radial facet; radial facet about 1/4 radial width, declivate, semicircular to horseshoe-shaped. Primanal same size as radials, smooth, without facet but with strong tubercle at point where 2 vertical ridges meet, with single ridge continuing from this tubercle to distal margin, with distal margin

FIG. 19. *Oehlerticrinus lemenni* sp. nov. all from NMVPL229. A,B,F, holotype cup and stem NMVP109213. A, lateral C ray view, ×4. B, lateral A ray view, ×4. F, oblique posterior tegminal view, ×7. C, lateral C ray view NMVP109098, ×3. D, partial crown NMVP109164, ×4. E, crown NMVP109116, ×2.5.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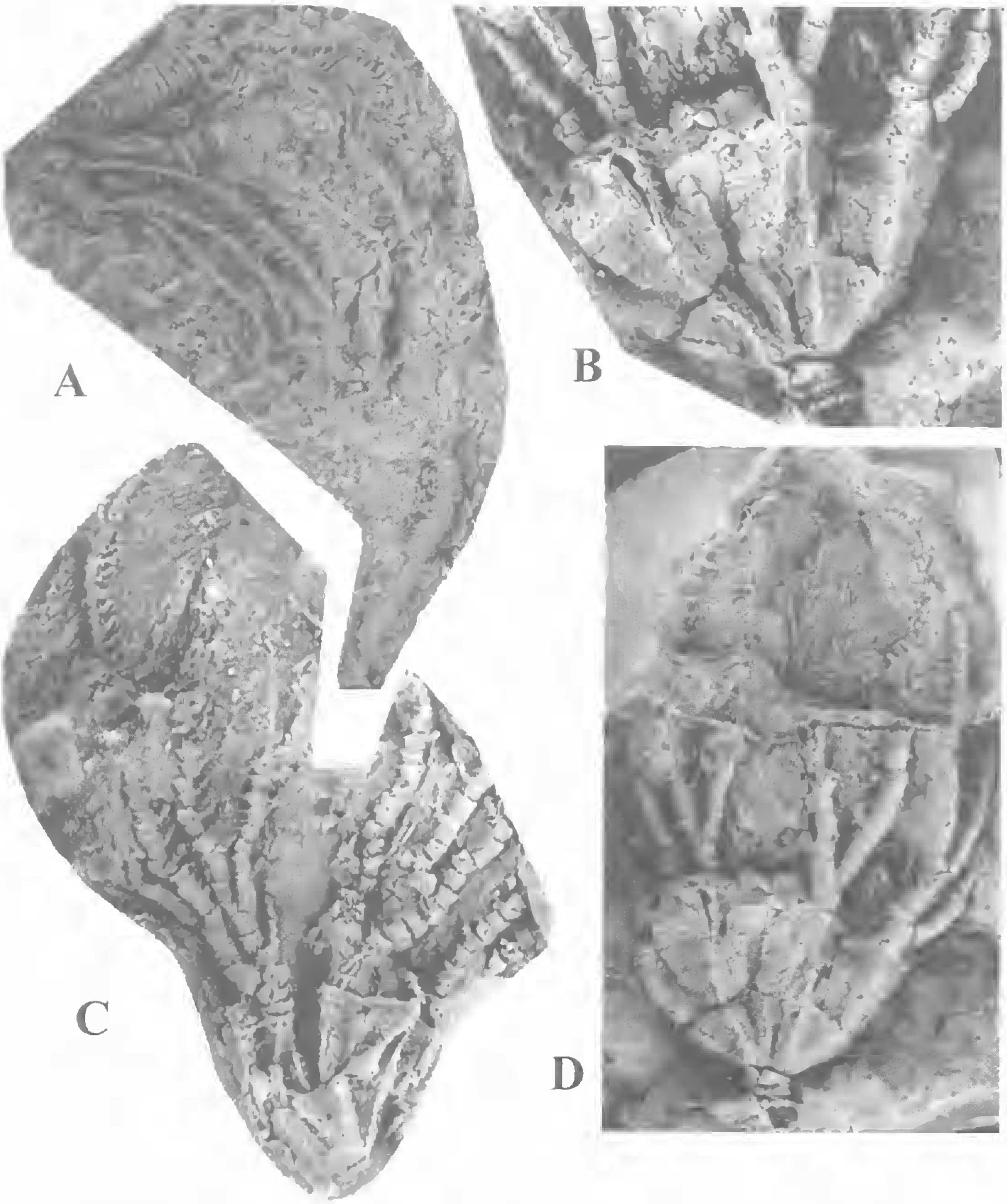
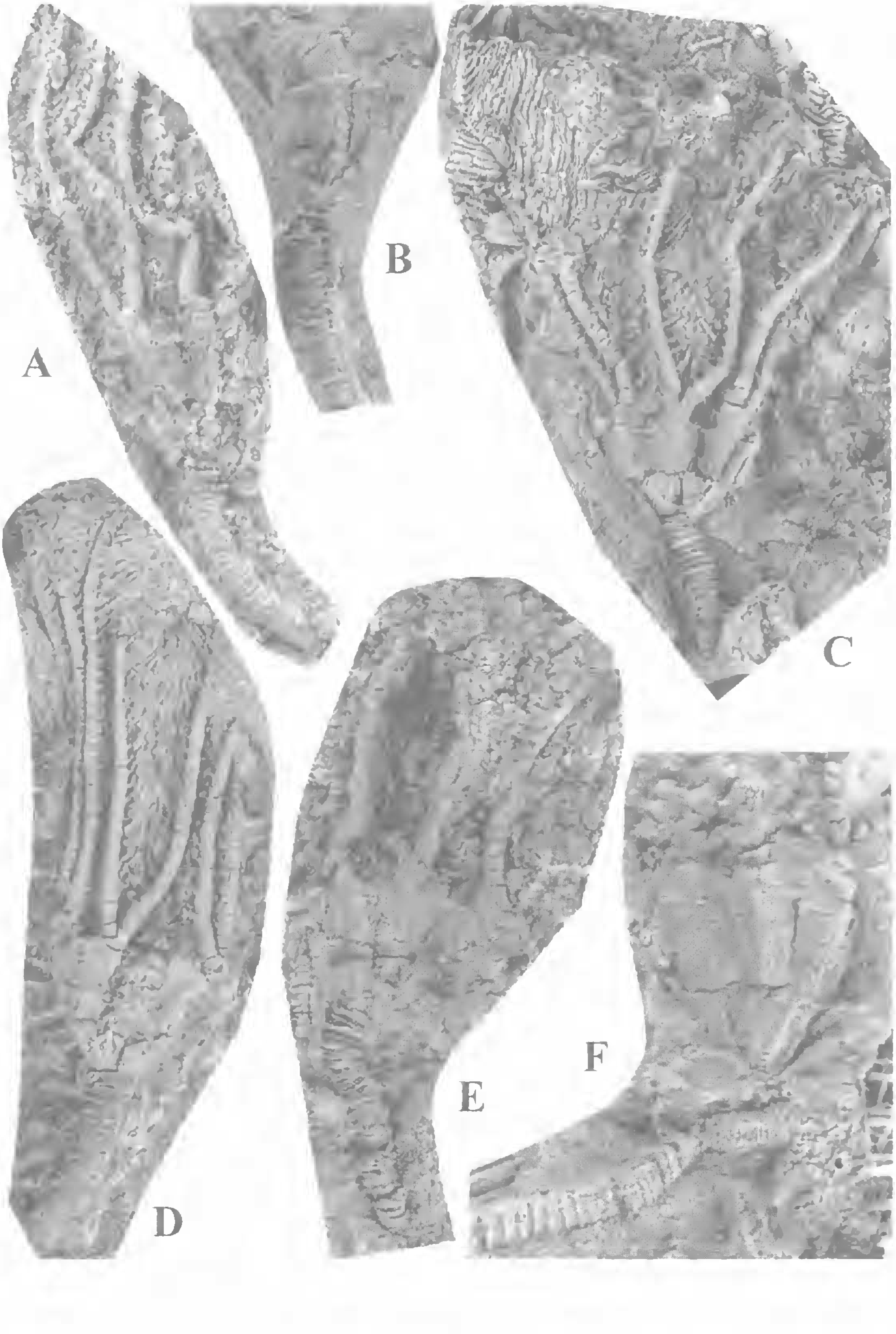


FIG. 20. *Oehlerticrinus lemenni* sp. nov. all from NMVPL252. A, crown with indistinct preservation of cup plates NMVP108682a, ×2.5. B,D, enlargement of cup and crown NMVP108679, ×6 and ×4, respectively. C, crown NMVP108672, ×5.

FIG. 21. *Oehlerticrinus jeani* sp. nov., all crowns (B and F with arms missing) from NMVPL252. A, NMVP108613, ×2.5. B, NMVP108664, ×3.5. C, holotype NMVP108626a, ×2.5. D, NMVP108614, ×2.5. E, NMVP108666, ×4. F, NMVP108618, ×6.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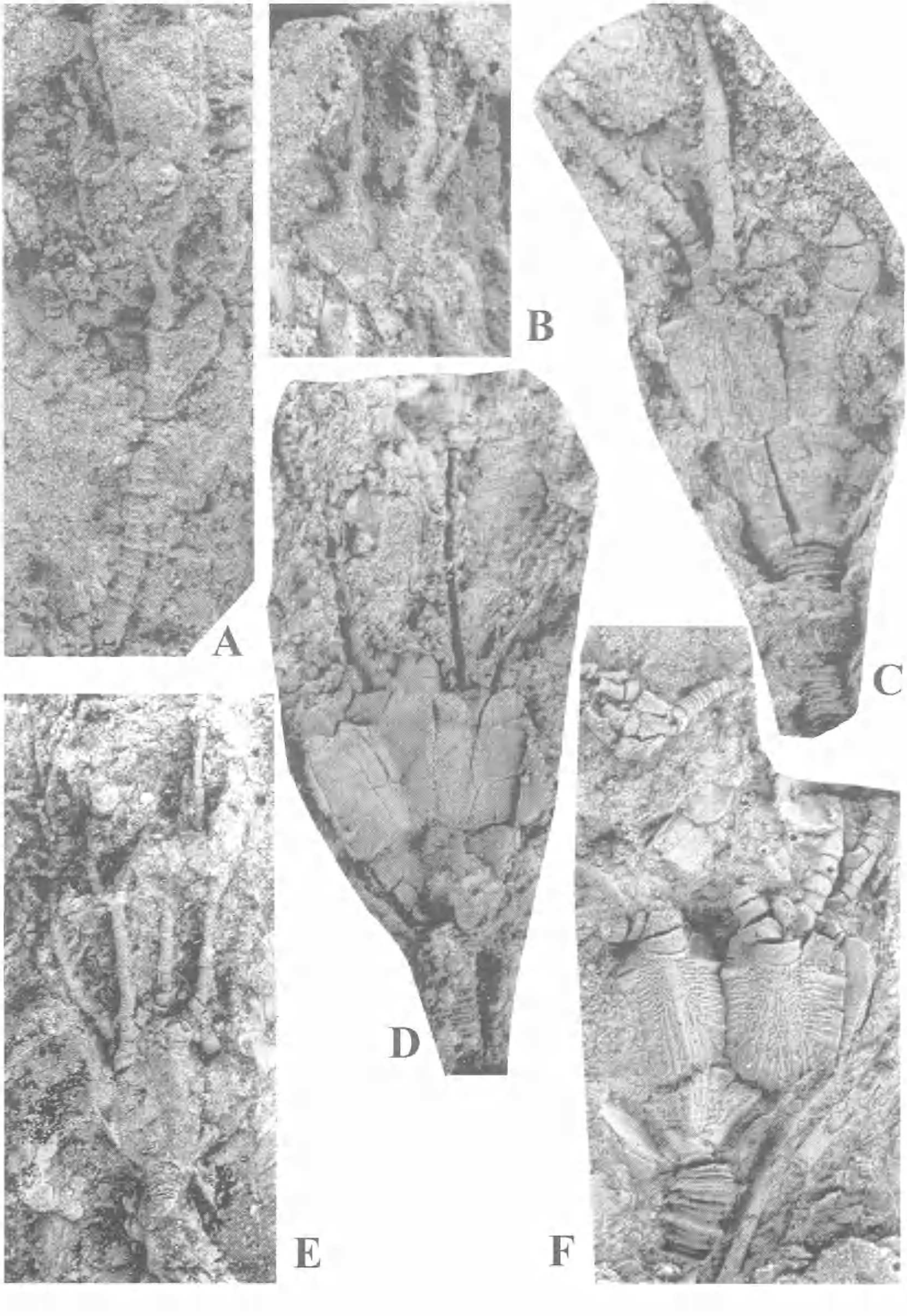
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of 2 straight sections, supporting 2 large anal plates. Arms 20, 4 per ray, rectilinear uniserial, usually with fine close-spaced longitudinal ridges, more than twice as long as cup. Second primibrach axillary, pentagonal; secundibrachs 4 per arm, 4th axillary, subquadrate in lateral view, almost circular, apparently not pinnulate; tertibrachs becoming cuneate distally, with large well-developed facet for attachment of pinnules; pinnules one per brachial, alternating from side to side along each arm. Tegmen with 5 large subtriangular interambulacral plates each resting symmetrically on 2 radials, with small irregular ambulacrals. Stem circular in section, with strongly crenulate sutures between columnals throughout; proximal section of low columnals with lateral flange at midlength, with flange slightly wider on nodals, noditaxis N212; distal section with longer (as long as 2 proximal columnals) columnals, with lateral midlength flange occupying only small part of length of nodals; internodals without lateral flange; noditaxis N1.

REMARKS. This species is distinguished from European members of the genus by its ornament, uniserial arms and noncirriferous stem. It is separated from *O. jeani* sp. nov. by its ornament and by its 20 rather than 10 arms.

Oehlerticrinus jeani sp. nov.
(Figs 21, 22)

ETYMOLOGY. For Jean Le Menn, the author of the genus.

MATERIAL. HOLOTYPE: NMVP108626. PARATYPES: NMVP 108613, 108614, 108618, 108664, 108666, 108667, 110641, 149375, 149376 all from NMVPL252; NMVP109150 from NMVPL229.

DIAGNOSIS. Cup ornament of low narrow ray ridges single on A, C, and D radials, double on B and E radials and radianal, with slightly more prominent horizontal ridge around the cup just proximal to radial facet and incomplete at each facet, with secondary ornament of fine broken wavy linear ridges parallel to the main ridges. Primanal supporting 3 anal plates. Arms 10, uniserial, of cuneate brachials. Stem circular in section, heteromorphic with strongly crenulate intercolumnal suture, with columnals becoming longer distally.

DESCRIPTION. Crown up to 35mm long, subcylindrical, arms at least 3 times as long as cup. Cup high conical, consisting of basals, radials and primanal; cup plates with ornament of fine, often wavy ridges, occasionally anastomosing, sometimes incomplete and then almost tubercular, subparallel to main ray ridges and thus forming more or less triangular patterns between midlines of adjacent radials and line joining adjacent radial facets. Basals 3, equal, forming hexagonal circlet, symmetrically proximal to A, C and D radials, occupying about 1/3 of cup length, each with 3 ridges radiating from distinct rim around stem attachment. Radials 5, up to twice as long as wide, occupying about 2/3 of cup length, with narrow ray ridges continuing up from basals, with narrow horizontal ridge running around the cup just proximal to facet but usually incomplete at the midline of radials; A, C and D radials with single central ridge; B and E radials and primanal each with 2 ridges converging on base of radial facet; radial facet about 1/3 radial width, declivate, semicircular to horseshoe-shaped. Primanal same size as radials, without facet, with single vertical ridge continuing distal to level of radial facets to distal margin medially, supporting 3 anal plates distally. Arms 10, 2 per ray, uniserial; 2nd primibrach axillary, pentagonal; secundibrachs becoming cuneate, with large well-developed facet for attachment of pinnules; pinnules 1 per brachial, alternating from side to side along each arm, of 6-10 pinnulars. Tegmen with 5 large subtriangular interambulacrals each resting symmetrically on 2 radials, with small polygonal ambulacrals. Stem circular in section, with strongly crenulate sutures between columnals; proximally low columnals with lateral flange at midlength, with flange slightly wider on nodals, noditaxis N212; distal section of uniform columnals, longer (as long as 2 proximal columnals), with lateral midlength flange occupying only small part of length.

REMARKS. *Oehlerticrinus jeani* is distinguished from European species by its ornament, its 10 uniserial arms and its noncirriferous stem. It is distinguished from the closely related and co-occurring *O. lemenni* under that species above.

Available specimens have been crushed so that many plates have disslocated at sutures while

FIG. 22. *Oehlerticrinus jeani* sp. nov. A, crown NMVP108667 from NMVPL252, ×3. B, juvenile crown NMVP149375, from NMVPL252, ×4. C,D, external and internal of NMVP149376, ×3. E, crown NMVP109150 from NMVPL229, ×4. F, cup with some arm fragments (counterpart of Fig. 21C), holotype NMVP108626 from NMVPL252, ×4.

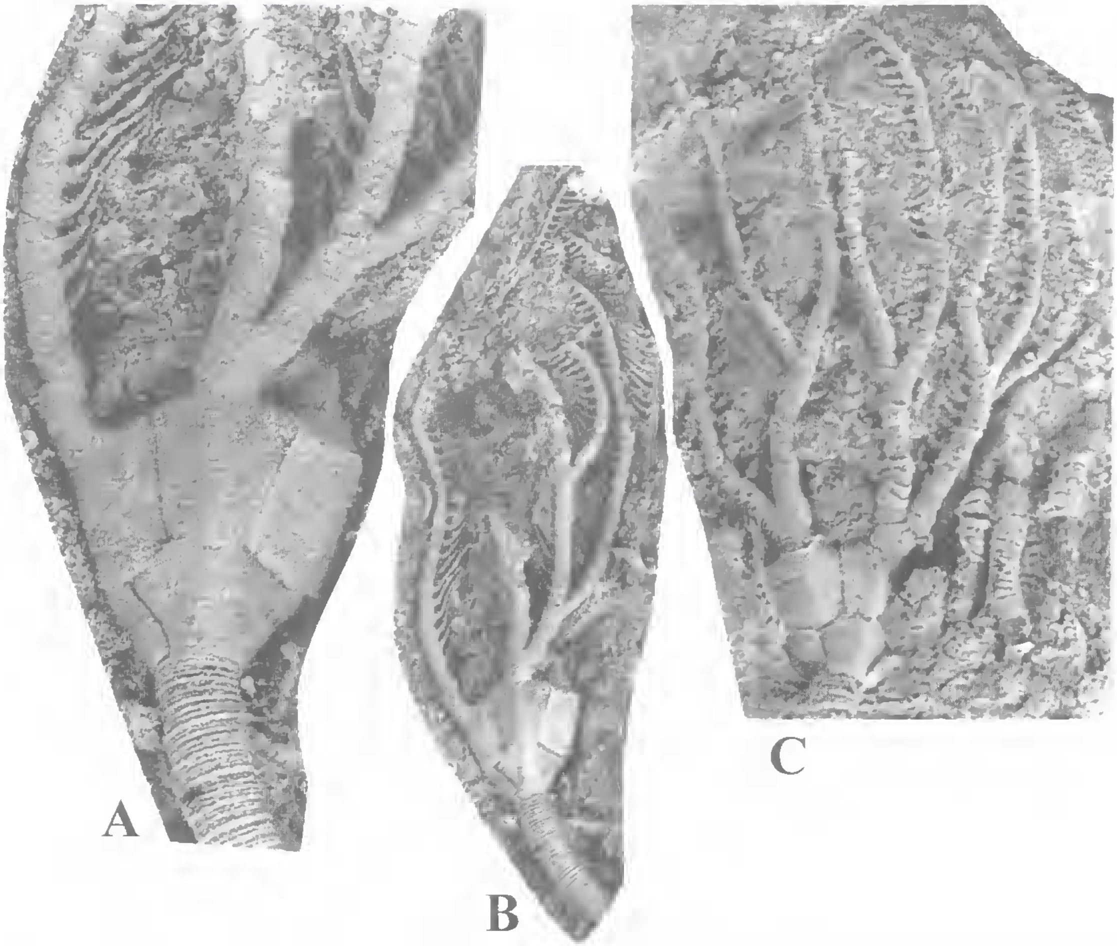


FIG. 23. *Frankocrinus holmesi* gen. et sp. nov. crowns from NMVPL229. A,B, holotype in D ray view NMVP109099, ×4 and ×1.4. C, NMVP109109, ×3.

others have fractured across the plate itself; this is particularly so near the upper margins of radial plates suggesting numerous reentrants into the radials. However, I have been unable to discern any clear pattern and maintain that the upper margins of the radials formed a smooth circle above which the tegmen was sutured.

Frankocrinus gen. nov.

TYPE SPECIES. *Frankocrinus holmesi* sp. nov.

ETYMOLOGY. For Frank Holmes of Melbourne.

DIAGNOSIS. Cup high conical, of smooth or finely ornamented plates. Radials with broad low ray ridges and horizontal flexure at level of radial facets, distal to which radials depressed between arms. Second primibrach axillary. Arms fixed in cup up to about 2nd or 3rd secundibrach. Single large interprimibrach extending proximally to level of radial facet in large excavation of distal corners of adjacent radials. Arms 20, uniserial, pinnulate. Stem circular in section, with crenulate intercolumnal sutures.

REMARKS. This genus is assigned to the Hexacrinitidae on the basic cup pattern of plates proximal to the radial facets. However, distal to the radial facets the arms are fixed in the cup which extends distally >1/2 length of the radials even though depressed between the arms. I suggest that this genus represents a further development from *Oehlerticrinus* in which the radials extend distal to the radial facets and there is a large interprimibrach resting on the straight upper margin of the radials; extension of the

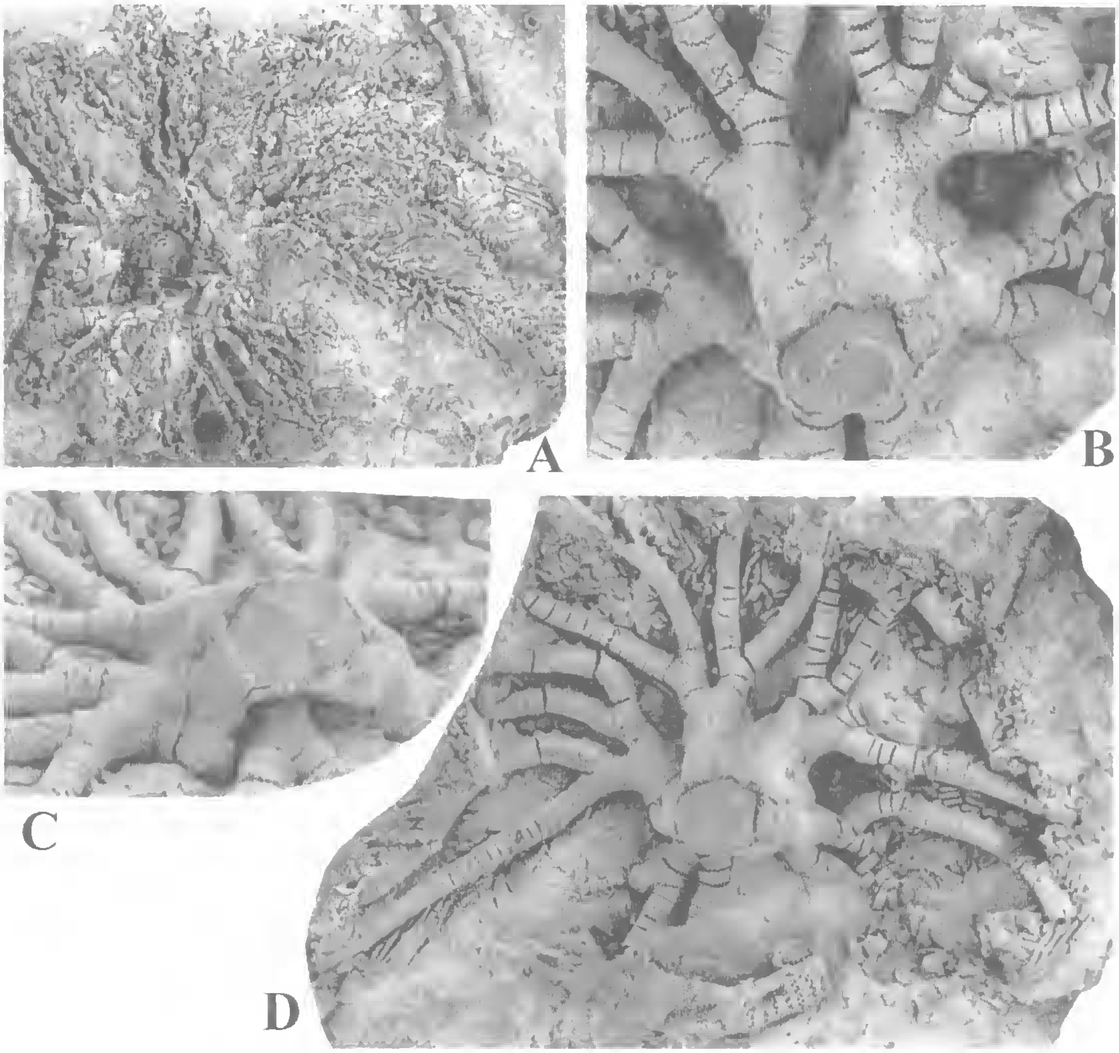


FIG. 24. *Frankocrinus emdae* gen. et sp. nov. splayed holotype crown NMVP108571 from NMVPL252. A, distal view of crown showing inner sides of arms, ×2. B, basal view with A ray at 11 o'clock, ×4. C, lateral view with cup inverted; D ray crushed under cup in forground, ×4. D, basal view with A ray at 12 o'clock, ×2.

interprimibrach proximally between the upper corners of the radials. radials smaller relative to size of cup than in other hexacrinitids and arms fixed in cup at least to the 2nd secundibrach are distinctive features of this genus. A comparable genus is *Cerasmocrinus* Strimple & Levorsen, 1973 from the Upper Devonian of Iowa in which the cup is typically hexacrinitid up to the radial facets and the arms are fixed in the cup and separated by a few large interprimibrachs up to at least the 1st secundibrach; that genus is separated from *Frankocrinus* by its flat wide primibrachs and 3 or more plates rather than one separating the fixed arms.

Frankocrinus holmesi sp. nov.

(Fig. 23)

MATERIAL. HOLOTYPE: NMVP109099. PARATYPE: NMVP109109 from NMVPL229.

DIAGNOSIS. Cup of smooth plates, with broad low angulation of the cup in position of ray ridges, with marked flexure around the cup at level of radial facet. Arms 20, fixed in cup up to 2nd secundibrach, uniserial, pinnulate, of

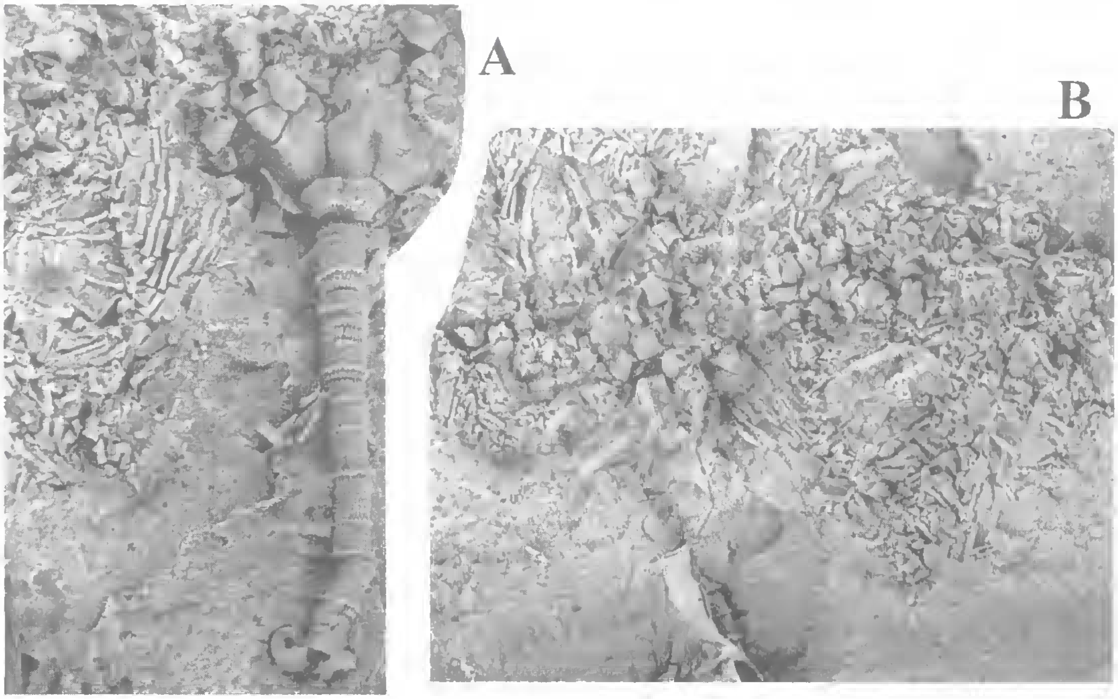


FIG 25. *Frankocrinus enidae* gen. et sp. nov. part and counterpart of paratype cup and stem in posterior view, with disarticulated arms above the cup NMVP108622 from NMVPL252, ×3.5.

cuneate brachials. Fixed arms separated by depressed areas each occupied by a single large interprimibrach, with a number of smaller tegmenal plates above that. Stem circular in section, heteromorphic, with crenulate intercolumnal sutures.

DESCRIPTION. Crown up to 45mm long, conical to subcylindrical. Cup high conical, consisting of basals, radials and primanal; ray ridges low, broad, indistinct. Basals 3, equal, forming hexagonal circlet, symmetrically beneath A, C and D radials, occupying about 1/3 of cup height, each with vertical median ridge. Radials 5, only slightly longer than wide, occupying about 2/3 of cup length, with broad low ridges continuing from basals; A, C and D radials with single central ridge; B and E radials and primanal each with 2 ridges converging on base of radial facet; radial facet a little more than 1/3 radial width, almost horizontal, subsemicircular, proximal to the distal margin of radial. Primanal same size as radials, smooth, supporting 3 large plates. Arms 20 or more, uniserial, more than 4 times as long as cup. Second primibrach axillary, pentagonal; secundibrachs 6-10 per arm, cuneate, almost circular in section, pinnulate; tertibrachs cuneate, pinnulate, with large well-developed facet for attachment of pinnule on longer side; pinnules one per brachial, alternating from side to side along each arm, long, well spaced. Tegmen of small polygonal plates. Stem circular in section, with strongly crenulate sutures between columnals, heteromorphic; proximal section of low columnals with epifacet slightly wider on nodals, noditaxis N1.

REMARKS. This species is distinguished from *F. enidae* by its smooth plates, longer radials and greater number of secundibrachs per arm.

Frankocrinus enidae sp. nov.
(Figs 24, 25)

MATERIAL. HOLOTYPE: NMVP108571. PARATYPE: NMVP108622 from NMVPL252.

DIAGNOSIS. Crown with external finely punctate ornament. Radials smaller relative to cup size than in other hexacrinitids. Arms 20, fixed in cup up to 2nd secundibrach, uniserial, pinnulate, of cuneate brachials, with strongly crenulate interbrachial sutures. Fixed arms separated by depressed areas occupied by single large interprimibrach. Stem circular in section, with crenulate attachment suture.

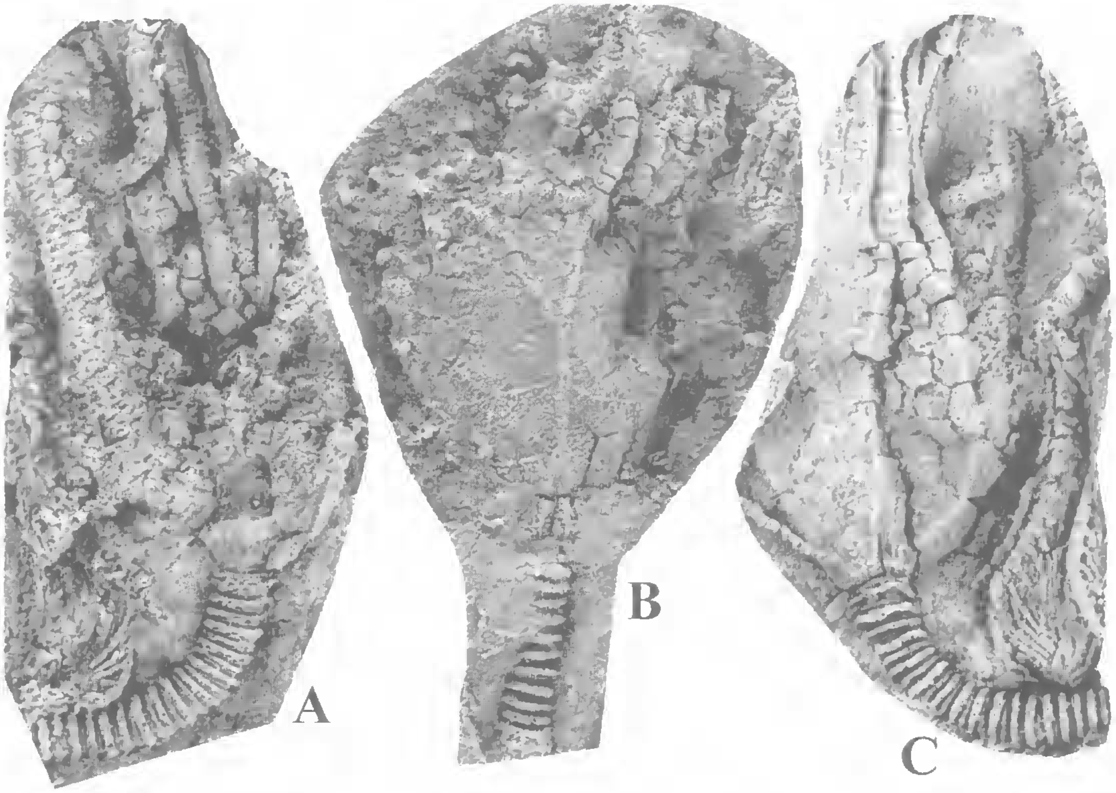


FIG. 26. *Alisocrinus lineatus* sp. nov. incomplete crowns from NMVPL300. A, C, part and counterpart of paratype NMVP109791, ×3. B, C ray view of holotype NMVP110632, ×3.

DESCRIPTION. Crown estimated to be 35mm long, conical. Cup high conical, consisting of basals, radials and primanal, with ray ridges low broad indistinct. Basals 3, equal, hexagonal, symmetrically proximal to A, C and D radials, each with vertical median ridge. Radials 5, only slightly longer than wide, with broad low ridges continuing from basals; radial facet about 2/3 radial width, declivate, subsemicircular. Primanal same size as radials, smooth, without facet. Arms 20, uniserial, with deep groove on inner side; 2nd primibrach and secundibrach axillary, pentagonal; tertibrachs cuneate, almost circular in section, pinnulate, with large well developed facet for attachment of pinnule; pinnules one per brachial, alternating from side to side along each arm, long, well spaced. Tegmen of small irregular polygonal plates. Stem circular in section, with strongly crenulate sutures between columnals, noditaxis N1 with lateral flange at midlength of latus slightly wider on nodals, with columnals increasing gradually in length distally, with lateral midlength flange occupying only small part of length, with large circular central lumen.

REMARKS. This species is distinguished from *F. holmesi* under that species above. The basal circlet crushed up into the calyx of the holotype makes determination of proportions impossible and has broken and concealed the primanal (at 5 o'clock Fig. 24D) masking features of the posterior of the cup. Ornament is a little more linear on the paratype but nevertheless it is still punctate as in the holotype. Crown length or shape is not available due to presevational features.

Suborder GLYPTOCRININA Moore, 1952
Superfamily MELOCRINITOIDEA d'Orbigny, 1852
Family MELOCRINITIDAE d'Orbigny, 1852

The evolutionary lineage outlined by Kirk (1929), Ubaghs (1958) and Brower (1976) beginning in the Ordovician Glyptocrinidae, through *Alisocrinus*, *Ctenocrinus*, *Melocrinites* and to

Trichotocrinus in the Middle Devonian is accepted, as are the generic concepts of those authors. However, Kesling's (1964) comment that the concepts of several type species are so poorly understood that he considered *Ctenocrinus* among other genera to be synonymous with *Melocrinites* is equally applicable to the myriad of species assigned to these genera. More than 40 specific names are currently included in *Ctenocrinus* and doubtless this is a figure inflated by intraspecific variation and preservation and failure on the part of several authors to recognise growth series. It is not the aim of this paper to assess these essentially European and North American taxa; I have illustrated many specimens of this very common element of the Victorian fauna to facilitate future species level revisions of the family. Assignment to established species from the Northern Hemisphere is a deliberate effort to avoid introducing new names into an already overcrowded arena. These are the closest known species available but future work on the status of known species could change the concept of any or all of the 3 and could necessitate reassignment of the Australian material. My assignments are made by comparisons with published illustrations, not all of them photographic, which may require reassessment.

Alisocrinus Kirk, 1929

TYPE SPECIES. *Mariacrinus warreni* Ringueberg, 1888 from the Middle Silurian of New York; by original designation.

DIAGNOSIS. See Ubaghs (1978).

Alisocrinus lineatus sp. nov.
(Fig. 26)

ETYMOLOGY. Latin *lineatus*, linear, for the ornament.

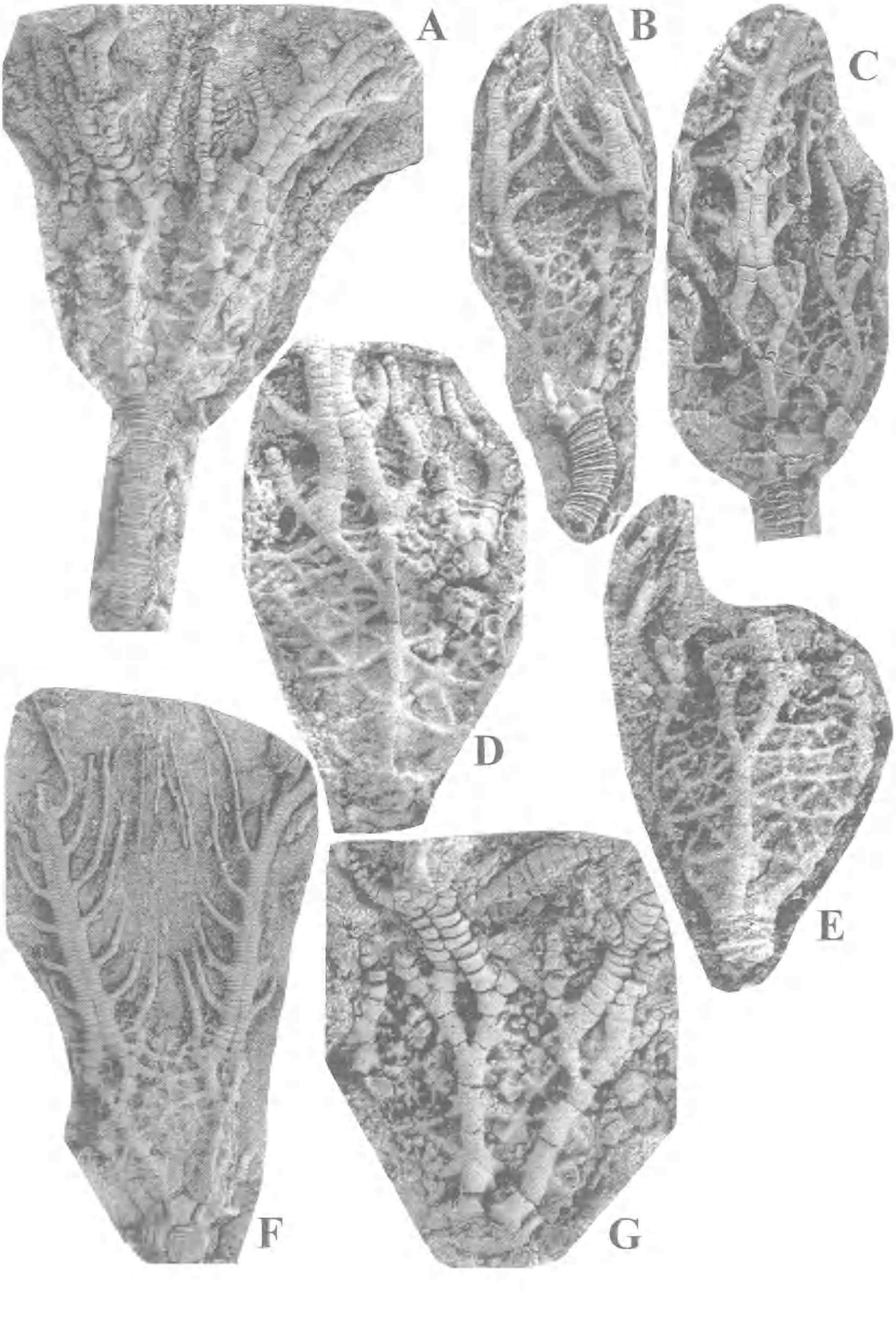
MATERIAL. HOLOTYPE: NMVP110632. PARATYPE: NMVP109791 from NMVPL300.

DIAGNOSIS. Cup plate ornament of narrow low ray ridges and fine radial ridges on a background of fine tubercles. Arms fixed in cup up to 1st tertibrach, 4 per ray, uniserial, of cuneate brachials; 2nd primibrach and 3rd secundibrach axillary.

DESCRIPTION. Crown up to 35mm long, subcylindrical. Cup high, conical, up to 15mm long; cup plates large, thin, with ornament of radial ridges (including ray ridges) and fine raised incomplete and irregular comarginal growth bands (so incomplete as to be simply a fine tuberculate ornament on most plates). Basals 4, with 3 of them pentagonal, with one larger and hexagonal, with proximal margin as distinct rim to stem attachment, with fine continuous ray ridges diverging distally from midpoint of base to cross 2 distal sides at right angles, with extra central vertical ridge bisecting CD interray on posterior basal. Radials 5, heptagonal, largest plates in cup, with inverted Y-shaped ray ridges continuing from basals and onto 1st primibrach, with secondary radiating ridges horizontally onto adjacent radials and sloping onto 1st interprimibrachs, all ridges at right angles to sutures. Primanal heptagonal, resting on shoulders of 2 adjacent radials, supporting 3 plates above, with 7 fine radial ridges radiating from centre to middle of each side and beyond to contiguous plates. Anal interray wider than others, with large polygonal plates decreasing in size upwards (arrangement unclear on only available specimen). First primibrach hexagonal, with broad low median ray ridge running in vertical line, with fine ridges running diagonally to other 4 lateral sutured margins; 2nd primibrach axillary, heptagonal, with median ray ridge in Y-shape to enter 2 arms. Secundibrachs fixed in cup, hexagonal, as large as primibrachs, 3rd axillary. Arms 20, uniserial, free above 2nd division, tapering gently, with longitudinal grooves on outer side of arms; free brachials cuneate, with pinnules one per brachial alternating from side to side along each arm. Interprimibrachs numerous, not depressed, with single large plate in contact with 2 radials and 1st primibrachs and supporting next row of 2 interprimibrachs, with plates in subsequent rows becoming smaller and less regularly arranged; intersecundibrachs tiny by comparison, few in number, depressed, polygonal, irregularly arranged. Tegmen unknown. Stem circular, heteromorphic, with wider epifacet on nodals but all columnals of about same height.

REMARKS. This species is distinguished from the genotype by the finer ray ridges and 3 rather than 2 secundibrachs. It is separated from the other species of the genus by its generally finer plate ornament and 3 rather than 2 secundibrachs.

FIG. 27. *Ctenocrinus paucidactylus* (Hall, 1859), all crowns in lateral view from NMVPL229 except C from NMVPL252. A, NMVP149377, ×3.5 . B, NMVP109158, ×2.5. C, NMVP108583, ×3. D, NMVP110646, ×2. E, NMVP108961, ×3. F, NMVP109154, ×1.5. G, NMVP149378, ×2.


A
B
C
D
E
F
G

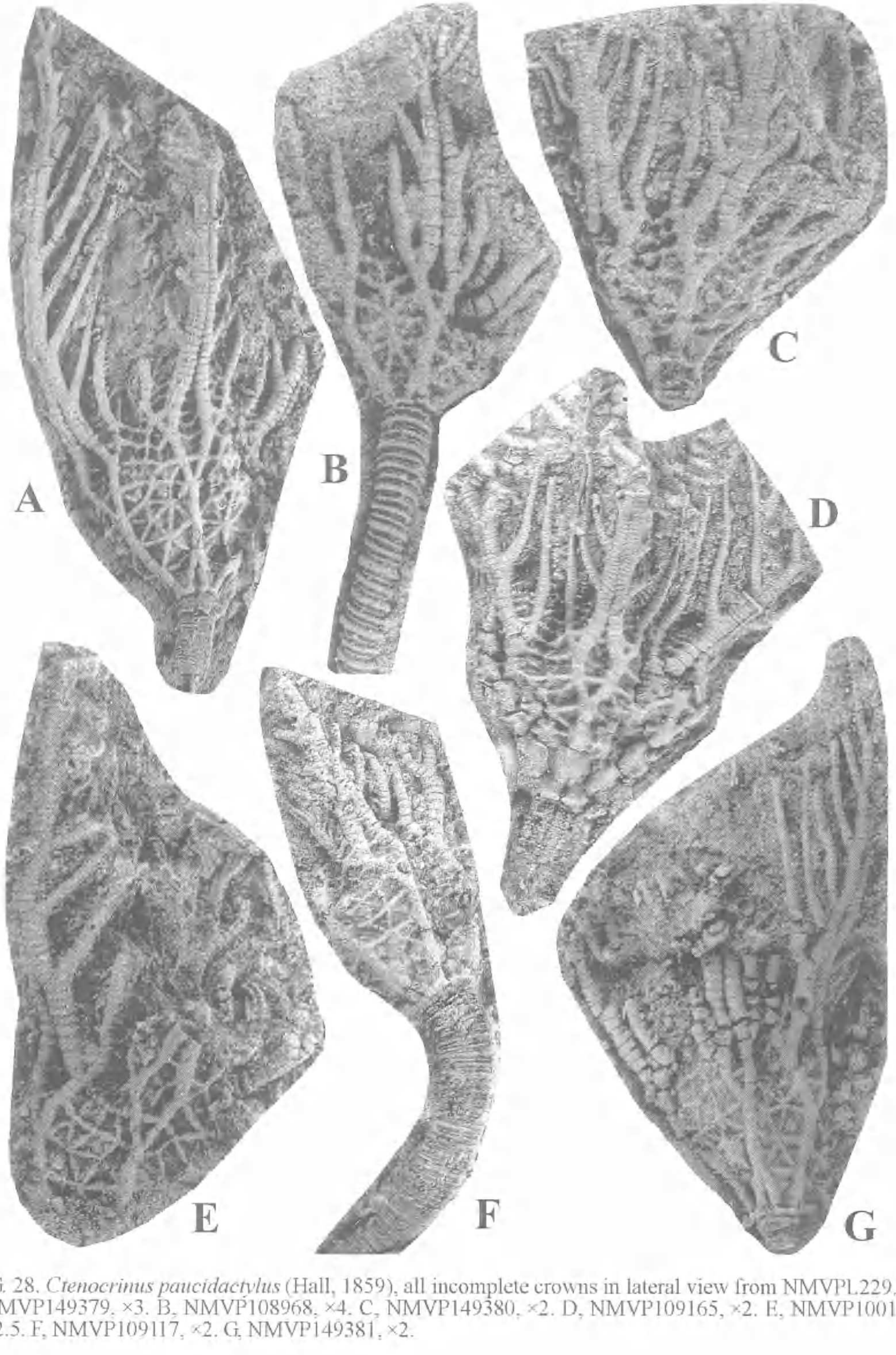


FIG. 28. *Ctenocrinus paucidactylus* (Hall, 1859), all incomplete crowns in lateral view from NMVPL229. A, NMVP149379, ×3. B, NMVP108968, ×4. C, NMVP149380, ×2. D, NMVP109165, ×2. E, NMVP100165, ×2.5. F, NMVP109117, ×2. G, NMVP149381, ×2.

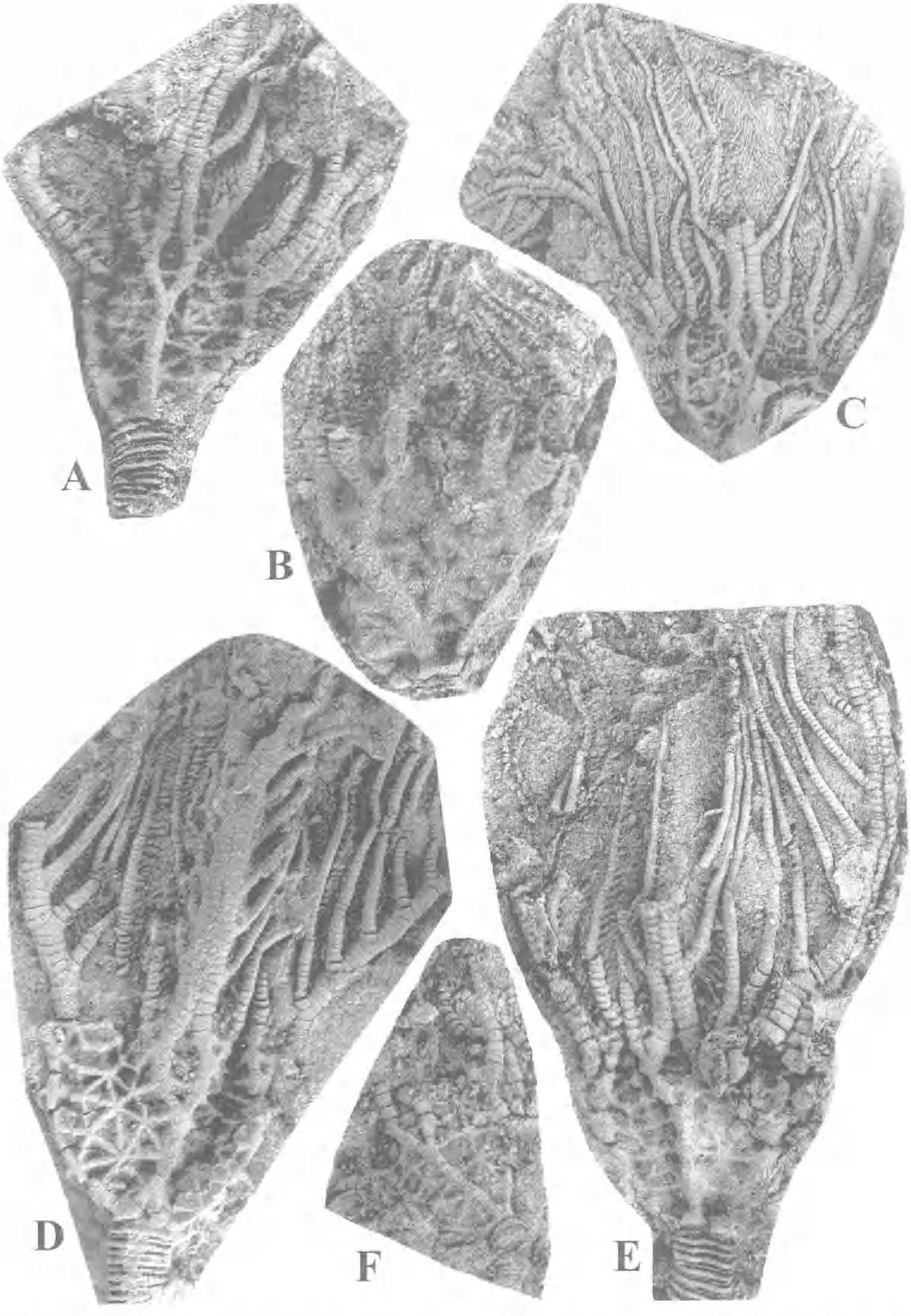


FIG. 29. *Ctenocrinus paucidactylus* (Hall, 1859), all incomplete crowns in lateral view from NMVPL229 except C from NMVPL252. A, NMVP109111, ×2.5. B, NMVP100168, ×2.5. C, NMVP108596, ×2.5. D, NMVP108610, ×2.5. E, NMVP108956, ×2.5. F, NMVP149382, ×2.5.

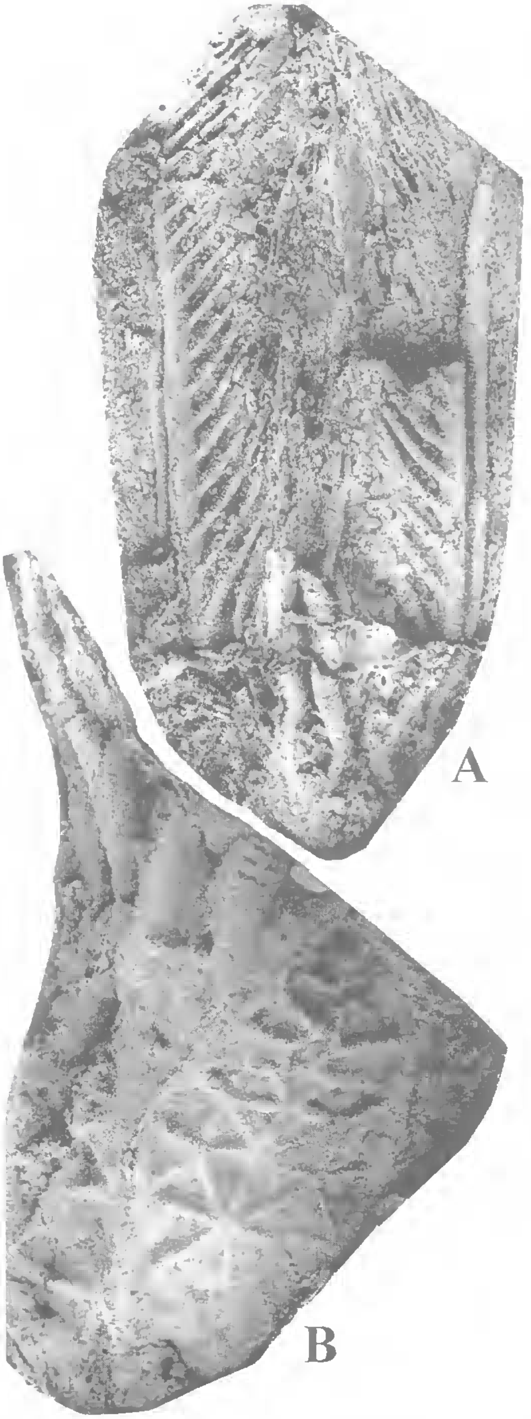


FIG. 30. *Ctenocrinus paucidactylus* (Hall, 1859), both from Locality 25, N of Heathcote (Talent, 1965). A, large set of arms with partial upper cup NMVP149356, ×1. B, large partial cup and arms NMVP149383, ×1.5.

Ctenocrinus Bronn, 1840

TYPE SPECIES. *Ctenocrinus typus* Bronn, 1840 from the Lower Devonian of Germany.

REMARKS. In light of the discussion under the family heading above I have not attempted to diagnose these species erected last century but have attempted to illustrate their features in the descriptions provided below. The description of the first species applies to all 3 in most features so descriptions of succeeding species are provided only where they differ from that of *C. paucidactylus*.

The species to which the Australian material is assigned belong to what Brower (1976) termed primitive *Ctenocrinus*.

Ctenocrinus paucidactylus (Hall, 1859)
(Figs 27-30, 31A-E)

MATERIAL. NMVP100165, 100168, 108685, 108956, 108961, 108964, 108968, 109111, 109117, 109127, 109154, 109158, 109165, 109168, 110646, 149377-149382 from NMVPL229; NMVP108583, 108596, 108610, 110636 from NMVPL252; NMVP149356 and 149383 from locality 25 in the Mt Ida Formation of Talent (1965, fig. 1).

DESCRIPTION. Crown up to 170mm long (NMVP148625), averaging 60-80mm long at NMVPL229 and 252. Cup high conical; surface of plates with strong radial ornament of narrow strongly convex ridges of uniform width throughout except for ray ridges being wider and more prominent than the rest. Basals 4, with interplate sutures at A, C, D and E rays, at least 4mm long. Radials 5, large, in contact laterally, 9mm long and 8mm wide at the widest point 3mm from the top, with 7 sides including horizontal distal margin and broadly chevron shaped proximal margin. First primibrach hexagonal, with horizontal proximal and distal margins, 7mm long by 6mm at greatest width near midlength. Second primibrach axillary, variously hexagonal or heptagonal, with strong dividing median ray ridge and markedly thinner and weaker radiating ridges laterally; 2nd secundibrach axillary, giving rise to larger inner arm trunk and smaller outer ramule. Arms 10, up to 4 times as long as cup, fixed in cup to about 3rd or 4th tertibrach; 2 arm trunks per ray laterally sutured into pseudobiserial structure, essentially a single arm, sharing a single groove down the inner side, with every 6-8th tertibrach axillary, 5-sided, with upper obtuse angle about midwidth of arm, branching off long uniserial pinnulate ramules at each axillary. Interprimibrachs

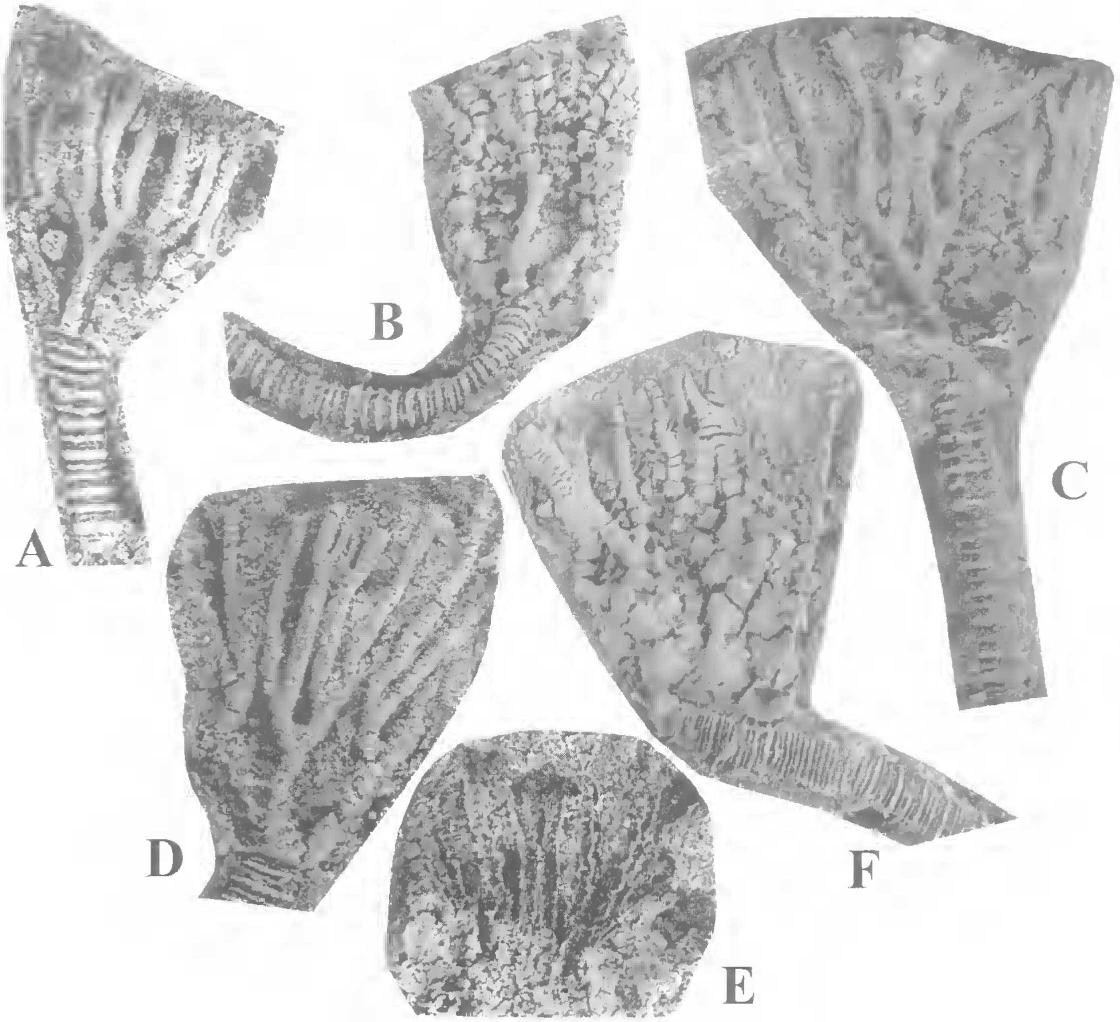


FIG. 31. A-E, *Ctenocrinus paucidactylus* (Hall, 1859), juvenile crowns all from NMVPL229 except C from NMVPL252. A. NMVP109127, ×3.5. B, NMVP108964, ×4.5. C, NMVP110636, ×3.5. D,E, exterior and inner side of arms, respectively NMVP108685, ×5. F, *Ctenocrinus signatus* Follmann, 1887, crown NMVP109152 from NMVPL229, ×2.

numerous, with large proximal one resting on shoulders of 2 radials, with striking ornament of high narrow radial ridges of uniform width (not expanded at centre of plate); 2nd row of 2 plates except in CD interray with 3 in 2nd row; subsequent rows less regular, of smaller plates, merging into the tegmen just above the fixed 2nd secundibrach. Intersecundibrachs 2, small, pentagonal, enclosed by large central arms in each ray, with central tubercle and weak radial ridges. Intertertibrachs between larger inner arm and first outer arm very small, irregular, up to 8, with central prominence on each and lateral ridges running between the inner and outer arms. Stem circular in section, heteromorphic, higher and wider nodals alternating with internodals.

Ctenocrinus stellifer Follman, 1887
(Figs 32-34)

MATERIAL. Syntypes of Follmann (1887, pl. 2, fig. 2, 2a,b) in the Bonn University Museum. Australian material assigned NMVP100175, 100188, 108584, 108589, 108597, 108603, 108658, 108684, 149384-149386 all from NMVPL252; NMVP149346 from NMVPL1990; NMVP149357 from NMVPL1841.

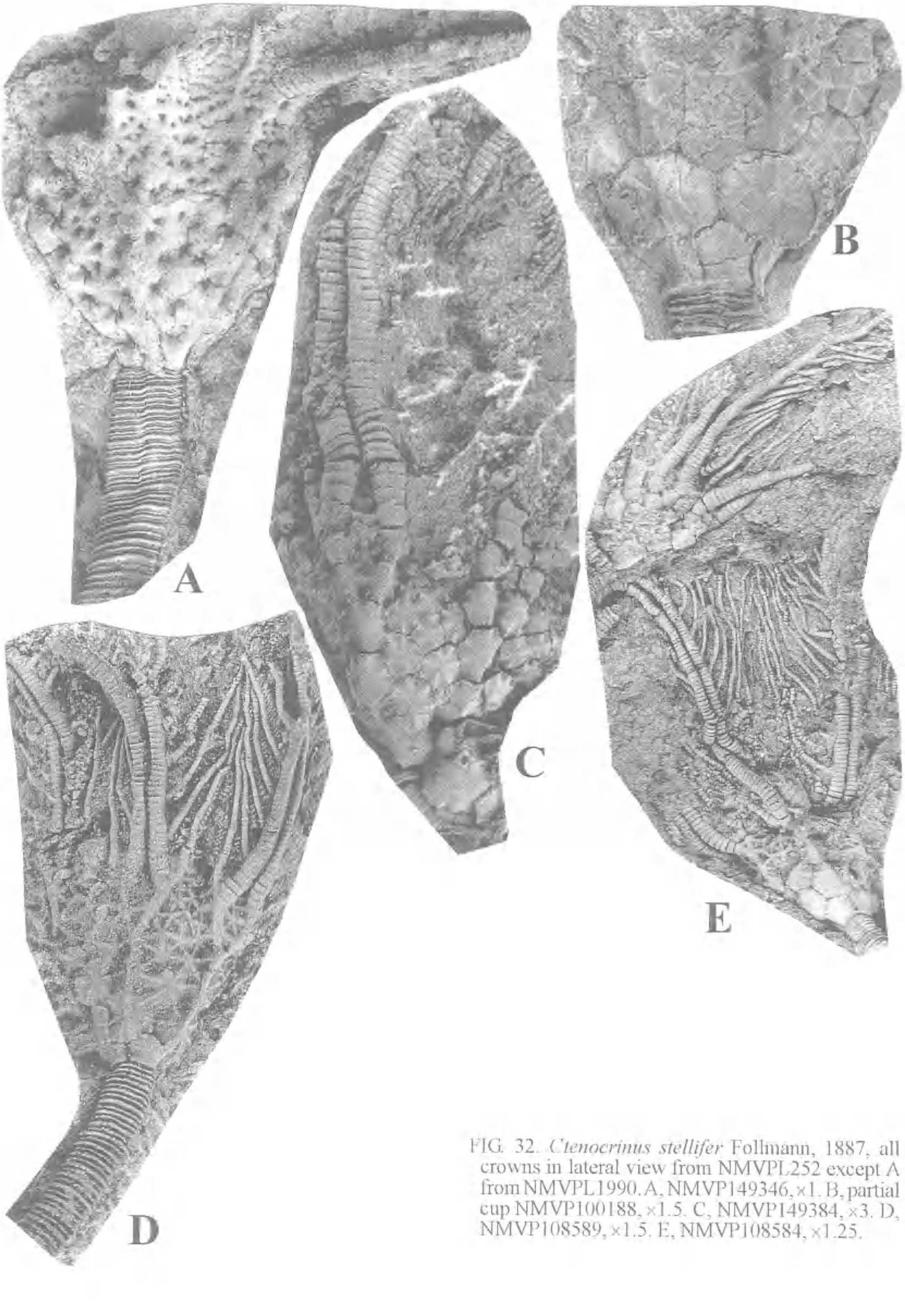


FIG. 32. *Ctenocrinus stellifer* Follmann, 1887, all crowns in lateral view from NMVPL252 except A from NMVPL1990. A, NMVP149346, ×1. B, partial cup NMVP100188, ×1.5. C, NMVP149384, ×3. D, NMVP108589, ×1.5. E, NMVP108584, ×1.25.

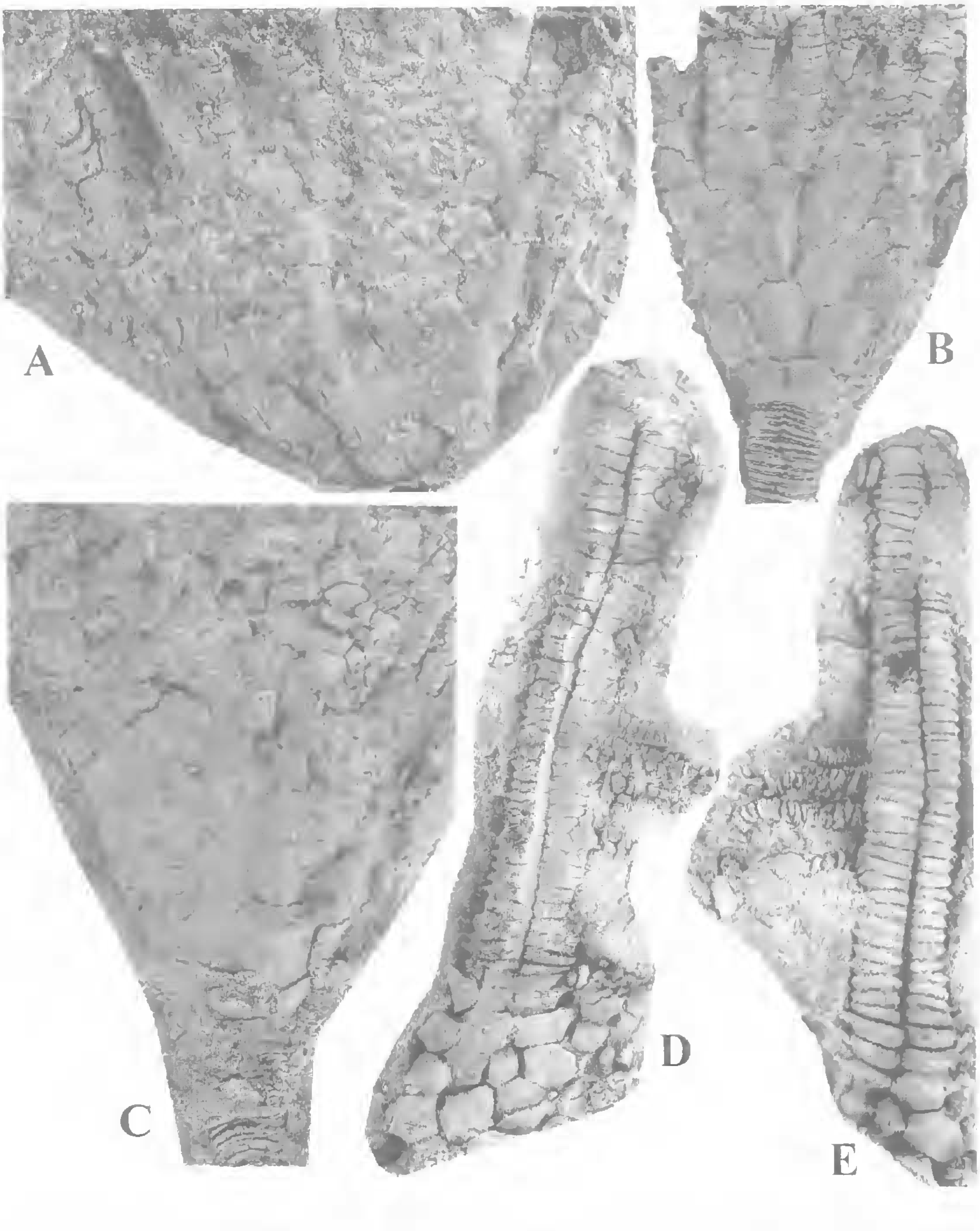


FIG. 33. *Ctenocrinus stellifer* Follmann, 1887. A-C, cups from NMVPL252. A, NMVP108597, ×2.5. B, NMVP108603, ×2. C, NMVP100175, ×2. D, interior and exterior of an arm NMVP149357 from NMVPL1841, ×1.5.

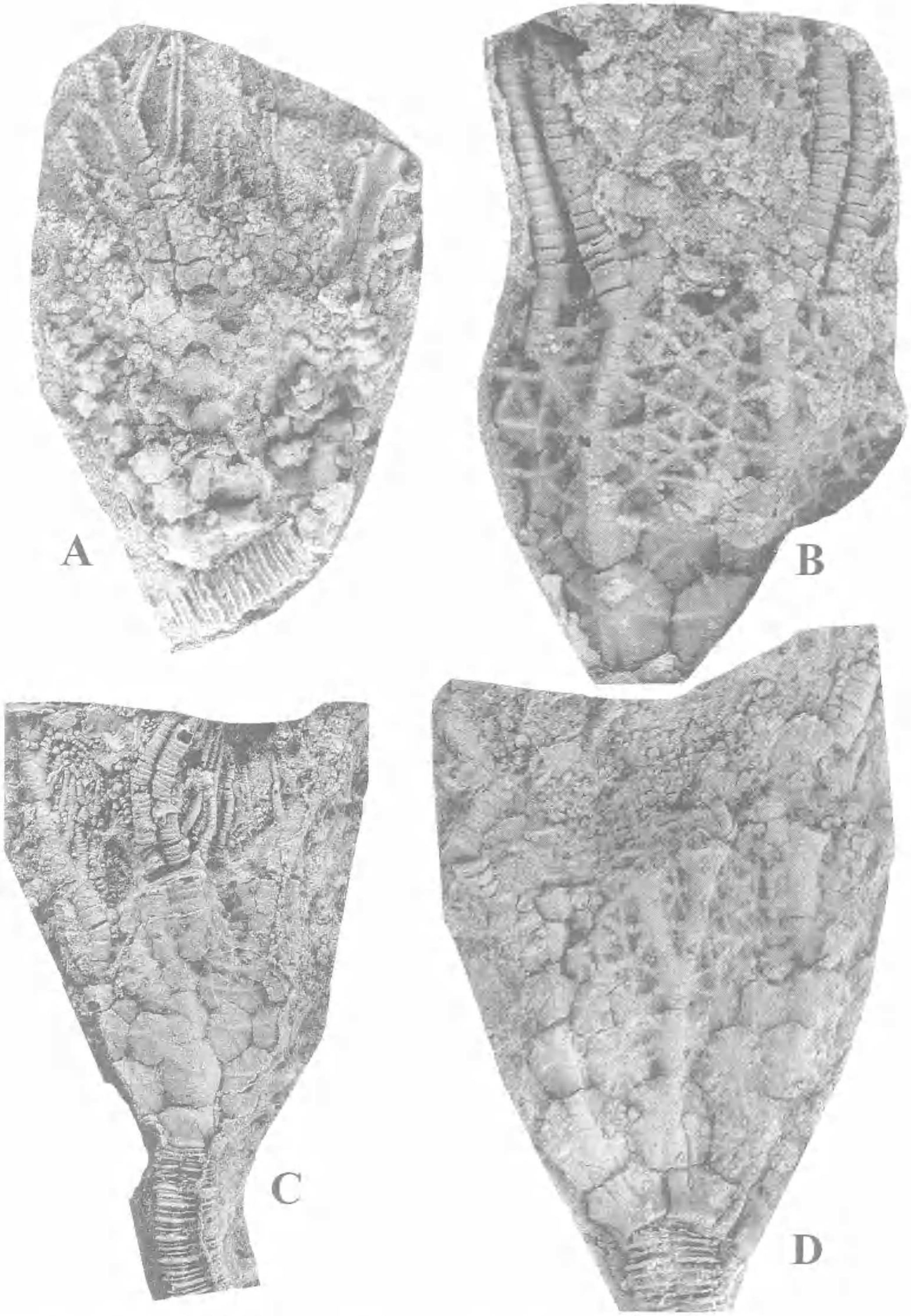


FIG. 34. *Ctenocrinus stellifer* Follmann, 1887, all crowns in lateral view (A interior view) from NMVPL252. A, NMVP149385, ×4. B, NMVP149386, ×3. C, NMVP108684, ×2. D, NMVP108658, ×3.

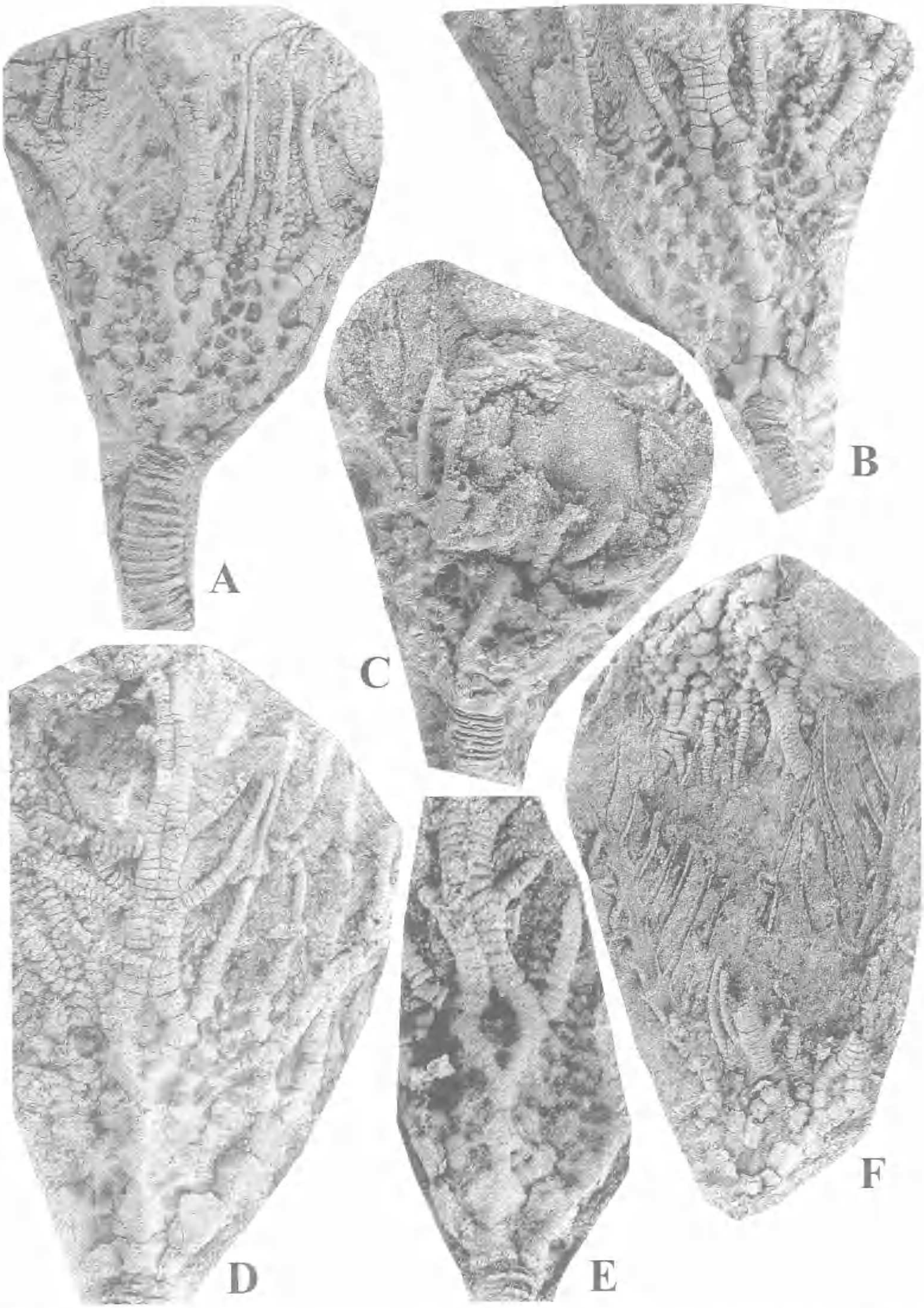


FIG. 35. *Ctenocrinus signatus* Schmidt, 1941, all crowns in lateral view from NMVPL252 except F. from NMVPL229. A, NMVP108609, ×2.75. B, NMVP108608, ×2.5. C, NMVP108601, ×2.5. D, NMVP109167, ×2.5. E, NMVP109104, ×3. F, NMVP149387, ×3.

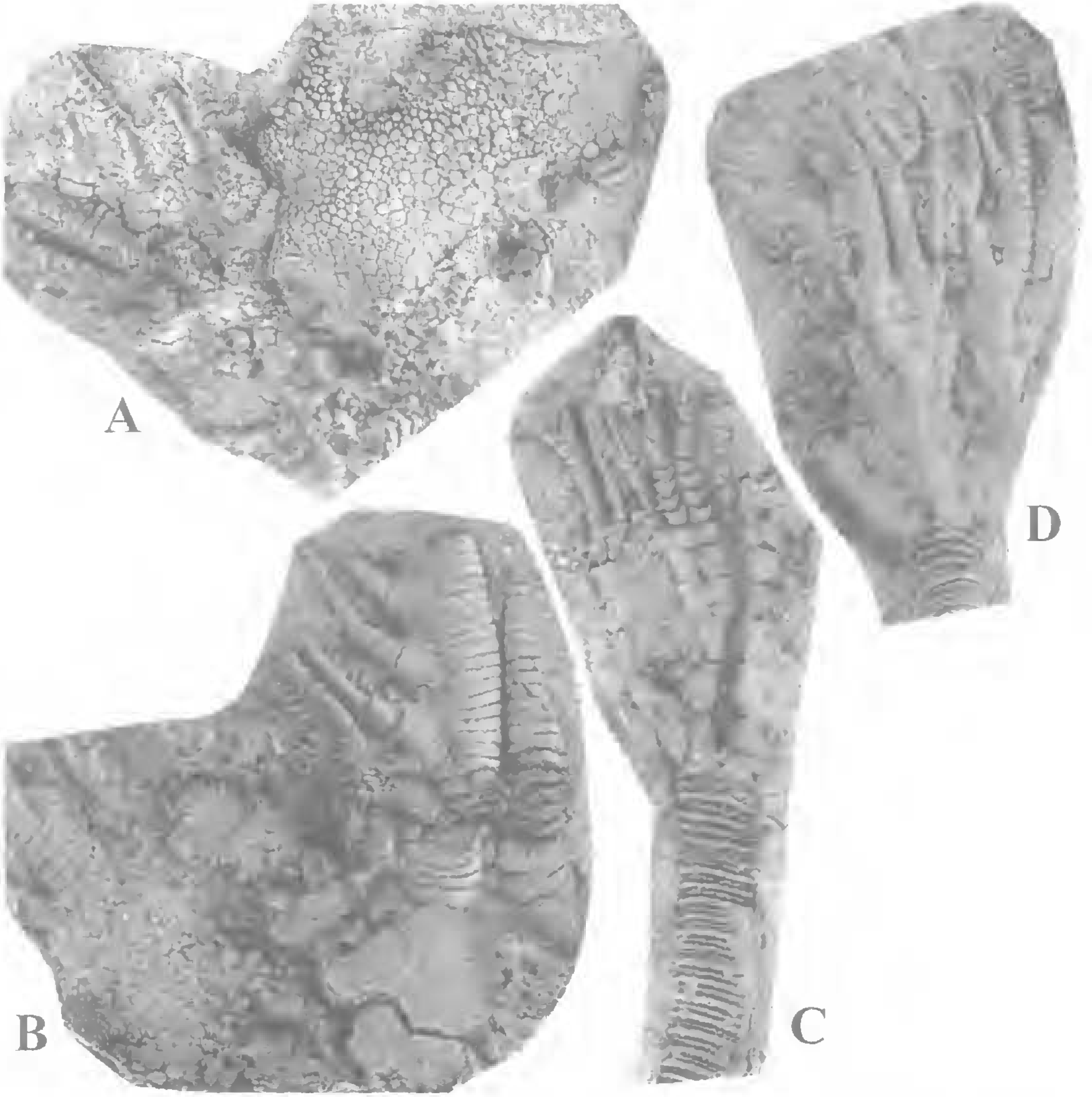


FIG. 36. *Ctenocrinus* sp. all from NMVP1924. A,B, part and counterpart of tegmen with some arm fragments NMVP109756, ×3. C, crown NMVP109750, ×2. D, crown NMVP109222, ×4.

DESCRIPTION. Crown up to 80mm long. Otherwise as for *C. paucidactylus* except: 1. plate ornament including the ray ridges, is greatly reduced on proximal parts of the cup; 2. tertiary ridges occur especially in the proximal plates of the cup parallel to the radial ornament; 3. 1st intersecundibrach with radial ridges running onto adjacent plates and producing distinctive 5-rayed star not evident in other Australian species; 4. ramules with axillary brachials slightly longer on outer side but otherwise no modification to arm trunk.

REMARKS. Reduced ornament on the proximal cup is clear on Schmidt's (1941, pl. 8, fig.4b) figure. Schmidt (1941, fig. 17) illustrated the tertiary ridges parallel to the radial ridges on proximal plates and the distinctive radial ornament of the 1st intersecundibrach. Follmann (1887, fig. 2, 2a,b) showed the last mentioned feature (fig. 2a) and the laterally longer axillary

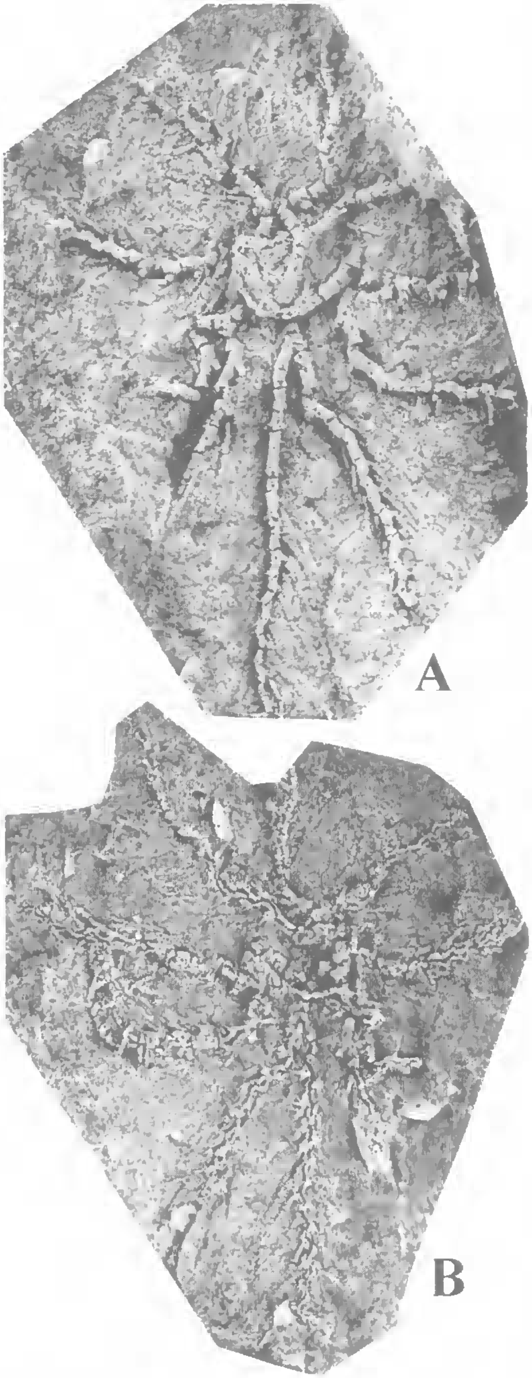


FIG. 37. *Hapalocrinus? victoriae* Bather, 1897, part and counterpart of splayed holotype crown NMVP386, from Yarra Improvement works near Prince's Bridge, ×2

brachials in the arm trunks; however, he showed a ramule arising about every 3rd or 4th brachial whereas the Australian species has upto 9 nonaxillary brachials in a row, averaging 6-8. Assignment to *stellifer* is made with slight reservation but it is a better match than with any other known species.

Ctenocrinus signatus Schmidt, 1941
(Figs 31F, 35)

MATERIAL. HOLOTYPE: in the Bonn Museum (Schmidt, 1941:73, fig 18a). Australian material assigned NMVP108601, 108608, 108609, 109167, 149387 from NMVPL252 and NMVP109104, 109152 from NMVPL229.

DESCRIPTION. Crown up to 70mm long. Otherwise as for *C. paucidactylus* except in relation to plate ornament as discussed below and in the branching of ramules where the axillaries in the arm trunks are quite asymmetrical, the facet for the ramule being much smaller and more lateral than that for the continuing central arm.

REMARKS. This species assignment is made principally on plate ornamentation which consists of a raised flat-topped central tubercle that is expanded laterally to occupy about half the plate area and from which the radial ridges radiate only a short distance so producing a stellate ornament. This ornament is unlike that of *C. paucidactylus* where the radial ridges maintain a uniform width even across the centre of the plate and even though it is subdued in some specimens (Fig. 35D) it is still much more pronounced than in *C. rhenanus* and it lacks tertiary ridges also.

Ctenocrinus sp.
(Fig. 36)

MATERIAL. NMVP109222, 109750, 109756 from NMVPL1924.

DESCRIPTION. As for *C. paucidactylus* except 1, plate ornament is virtually absent, although one specimen (Fig. 36D) retains a very subdued radial ornament on basals, radials and primibrachs. 2, the tegmen consists of a very large number of tiny polygonal plates, with a small diameter anal tube (broken base only on this specimen). 3, largest specimen with a fringe of tiny plates between bases of ramules adjacent to arm trunks. 4, brachials forming ramules with proximal and distal margins parallel in exterior view but cuneate in interior view.

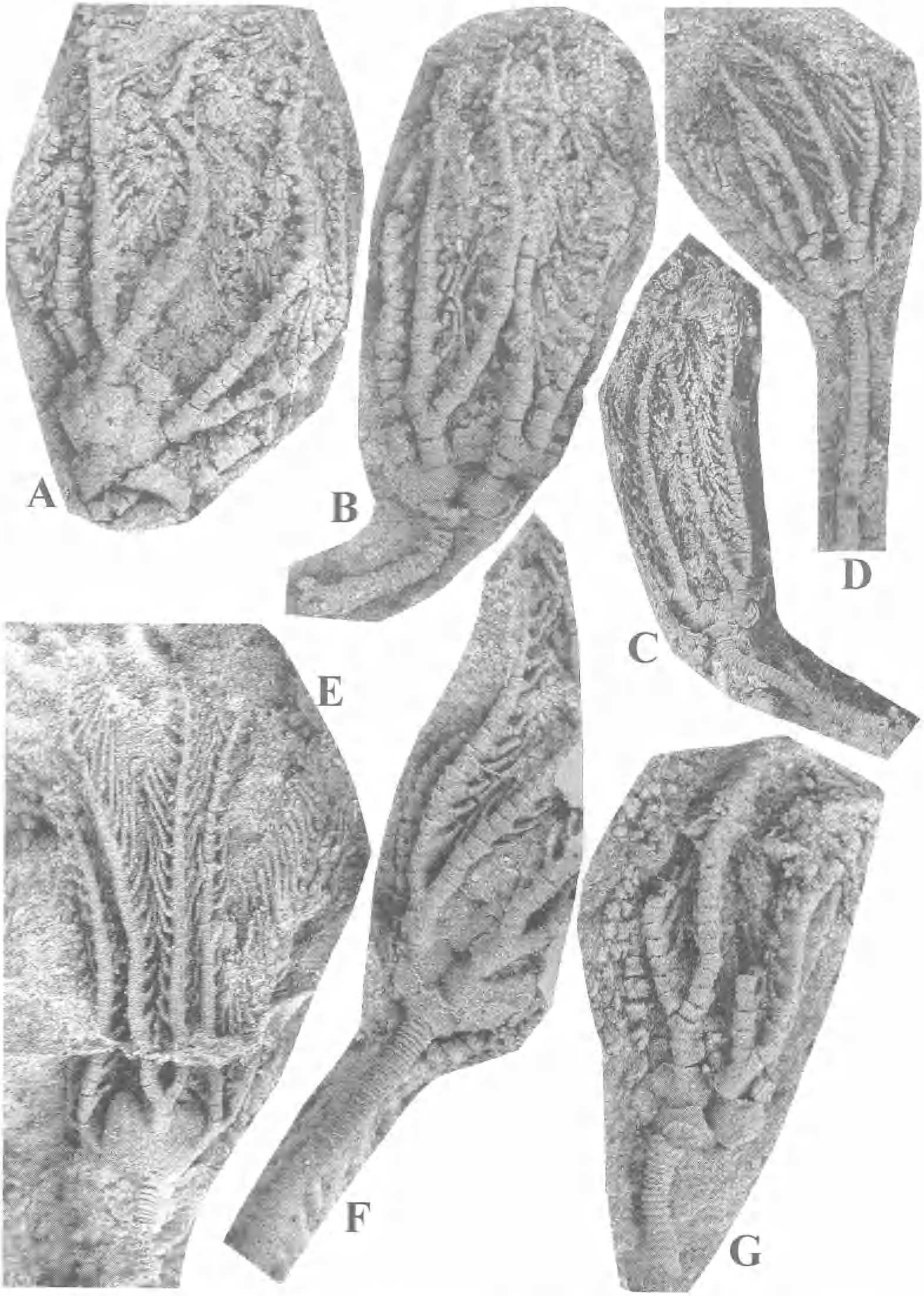


FIG. 38. *Clematocrinus perforatus* sp. nov., all crowns in lateral view from NMVPL300. A, NMVP109816, ×4.5. B, NMVP149388, ×4. C, NMVP109824, ×2. D, NMVP109821, ×4. E, NMVP109782, ×5. F, NMVP109785, ×5. G, NMVP109811, ×5.

REMARKS. This material with reduced plate ornament could be placed with *C. stellifer* from NMVPL252 but features listed above, in particular features of the mature arm and lack of ornament make such identification doubtful and it is best left in open nomenclature.

Superfamily PLATYCRINITOIDEA Austin & Austin, 1842
Family HAPALOCRINIDAE Jaekel, 1895

Hapalocrinus Jaekel, 1895

TYPE SPECIES. *Hapalocrinus elegans* Jaekel, 1895 from the Lower Devonian of Germany.

Hapalocrinus(?) victoriae Bather, 1897
(Fig. 37)

MATERIAL. NMVP386a and b from the Yarra Improvement Works near Prince's Bridge, Melbourne, in the Ludlovian Melbourne Formation.

DESCRIPTION. Crown splayed; form of cup uncertain, basal circlet not discernible. Radials 5, 7-sided (one being radial facet), smooth, widest at distal shoulders. Arms 10, up to 15mm long, with 3 primibrachs, 3rd axillary, uniserial, with well-developed facets for pinnule attachment giving zigzag appearance to arm; pinnules 1 per brachial alternating along each arm, widely separated, long (up to 5mm) and thin, with 4-6 long pinnulars; brachials rectangular, about twice as high as wide, with wide strongly zigzag groove on inner surface.

REMARKS. The detail of this specimen is not certain as was acknowledged by Bather (1897: 337, footnote 3) when he said he could not vouch for each line in his drawing. However, I agree with his general conclusions and only the nature of the basal circlet described by Bather is not readily apparent to me. Since so few features are available a separate diagnosis is not provided; the species is principally distinguished by its long brachials in the arms and is deliberately isolated on the type because of the difficulty of comparing other material with it.

Ausich (1986b) discussed this species in relation to Ubaghs' (1978b) tentative extension of the range of *Clematocrinus* to include Australia. I agree with Ausich's (1986b) conclusion supporting separation of the 2 genera and retain *victoriae* in *Hapalocrinus* based principally on the 3 primibrachs.

Bather (1897) noted that the counterpart of the type specimen was lost but part and counterpart have been reunited in the Museum of Victoria collection.

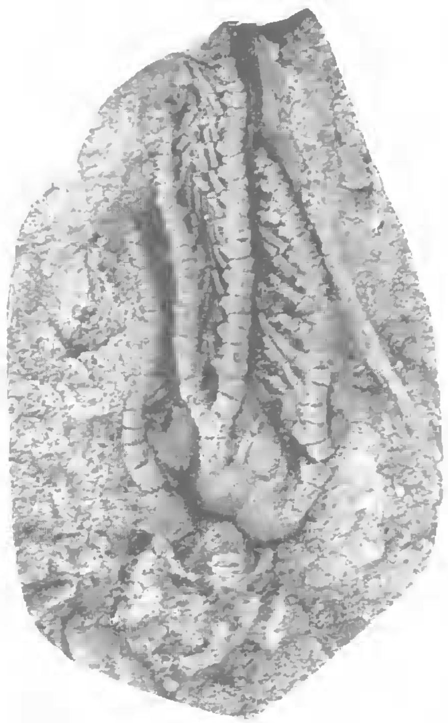


FIG. 39. *Clematocrinus perforatus* sp. nov., crown NMVP100185 from NMVPL252, ×3.

Clematocrinus Jaekel, 1898

TYPE SPECIES. *Actinocrinites? retiarius* Phillips in Murchison, 1839 from the Wenlock of England; by monotypy.

DIAGNOSIS. See Ausich, 1986b: 894.

REMARKS. Ubaghs (1978b:512) tentatively extended the distribution of this genus to include North America and Australia but as noted above there are no published records in Australia and *H. victoriae* cannot be considered a member of this genus. Ubaghs (1978b:518) suggested that Chapman's (1903) *Helicocrinus*, although of uncertain placement, might be a hapalocrinid but that genus is best isolated on the type specimen with features as noted below.

Clematocrinus perforatus sp. nov.
(Figs 38-40)

ETYMOLOGY. Latin *per-*, through and *foramen*, hole; referring to the stem appearing perforate.

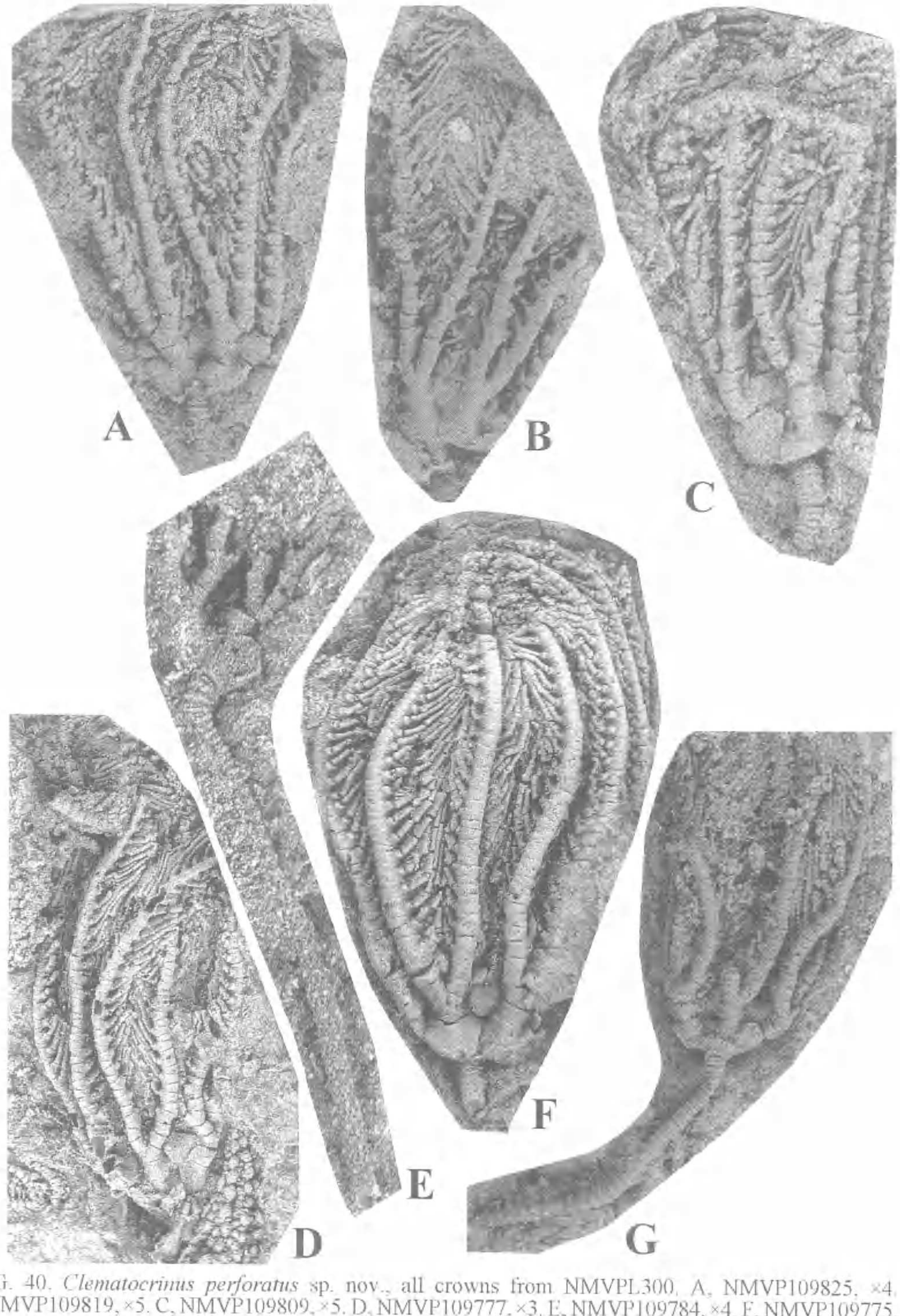


FIG. 40. *Clematocrinus perforatus* sp. nov., all crowns from NMVPL300. A, NMVP109825, ×4. B, NMVP109819, ×5. C, NMVP109809, ×5. D, NMVP109777, ×3. E, NMVP109784, ×4. F, NMVP109775, ×3. G, NMVP109826, ×4.

MATERIAL. HOLOTYPE: NMVP109782. PARATYPES: NMVP109775, 109777, 109782, 109784, 109785, 109805, 109809, 109811, 109816, 109819, 109821, 109824, 109825, 109826, 110624, 110627, 110628, 110629, 110631, 110633, 110642, 149388 all from NMVPL300; NMVP100185 from NMVPL252.

DIAGNOSIS. Cup bowl-shaped. Basal circlet apparently fused. Posterior interray with vertical anal tube of large polygonal plates. Arms 10, uniserial, of low subquadrate (in lateral view) cuneate brachials. Stem noncirriferous, with crenulate intercolumnal sutures, with columnals becoming longer and epifacet breaking up into an annulus of tubercles distally.

DESCRIPTION. Crown elliptical, 32mm long. Cup low bowl-shaped, about 5mm high, radially symmetrical except in posterior interray, without basal concavity. Cup plates smooth, thin, convex. Basals apparently fused into pentagonal unit, short in lateral view, with circular crenulate stem facet occupying central 1/2-2/3. Radials 5, forming complete circlet, largest plates in cup, occupying about 1/2 cup length, hexagonal, convex with distal corners depressed. Radial facet horizontal, just over half radial width. Arms 10, free distal to primaxil, uniserial; 1st primibrach subquadrate, with convex raised central part and depressed lateral flanges; 2nd primibrach pentagonal, axillary, fixed in cup, with depressed lateral flanges; brachials variable in proportions but usually wider than long, subquadrate proximally, rapidly becoming cuneate distally; pinnules 1 per brachial, alternating along each arm, long, becoming more slender distally, of long pinnulars (4-6 per pinnule). Proximal interprimibrach large, hexagonal, resting on depressed shoulders of adjacent radials, only interbrachial in cup; CD interray with row of 3 anal plates resting on shoulders of C and D radials, with interbrachials protruberant in elongate convex bulge; primanal central, pentagonal, smaller than proximal interbrachial of other interrays, flanked by smaller anal sac plates in contact with primibrachs. Tegmen with short stout anal tube at posterior. Stem circular in section, heteromorphic; proximally with alternating nodals and internodals of similar length but with epifacets or annular flange at midlength of latus being wider on the nodals; distally with uniform columnals, each with the epifacet at midlength of latus broken up into a circlet of small nodes; intercolumnal articulations symplexial, with culmina from one columnal not fitting neatly into opposing crenellae on next columnal so producing the effect of two adjacent circlets of pores around stem.

REMARKS. This species is distinguished within the genus by its distinctive stem, narrow radial facets, uniserial arms and posterior anal tube. Australian species do not closely resemble any of the other species and might ultimately prove separate generically but at present I cannot determine a clear diagnosis of such a genus and these species fit the current concept of *Clematocrinus*. Moreover, phylogeny within the family as in Ubaghs (1978b) is unclear and unnecessary introduction of further names seems unhelpful.

Clematocrinus argylensis sp. nov.

(Fig. 41)

ETYMOLOGY. From just east of the Argyle Railway Station near Heathcote.

MATERIAL. HOLOTYPE: NMVP109188. PARATYPES: 109189, 109193, 109201 from NMVPL2259.

DIAGNOSIS. Cup bowl-shaped. Posterior interray with vertical anal tube. Radials about half cup length, with extremely narrow radial facets less than half plate width. Arms 10, uniserial, of subrectangular (in lateral view) to cuneate brachials. Stem noncirriferous, with crenulate intercolumnal sutures, with columnals becoming longer and epifacet not breaking up into tubercles distally.

DESCRIPTION. Crown elliptical, 25mm long. Cup bowl-shaped, about 5mm long, radially symmetrical except for posterior interray, without basal concavity. Cup plates smooth, thin. Basals 3, fully exposed laterally, with circular crenulate stem attachment occupying central 1/3 of diameter. Radials 5, largest plates in cup, about 1/2 cup length, hexagonal; radial facet horizontal, about 1/3 radial width. Arms 10, free distal to primaxil, uniserial; 1st primibrach subquadrate, with convex raised central part and depressed lateral flanges; 2nd primibrach pentagonal, axillary, fixed in cup, with depressed lateral flanges; brachials variable in proportions but usually longer than wide, subpentagonal proximally, rapidly becoming cuneate distally; pinnules one per brachial, alternating along each arm, long, becoming more slender distally, of long pinnulars (4-8 per pinnule). Proximal interprimibrach large, hexagonal, resting on shoulders of adjacent radials, only interbrachial in cup; CD interray with row of 3 anal plates resting on shoulders of contiguous radials, with anals forming vertically

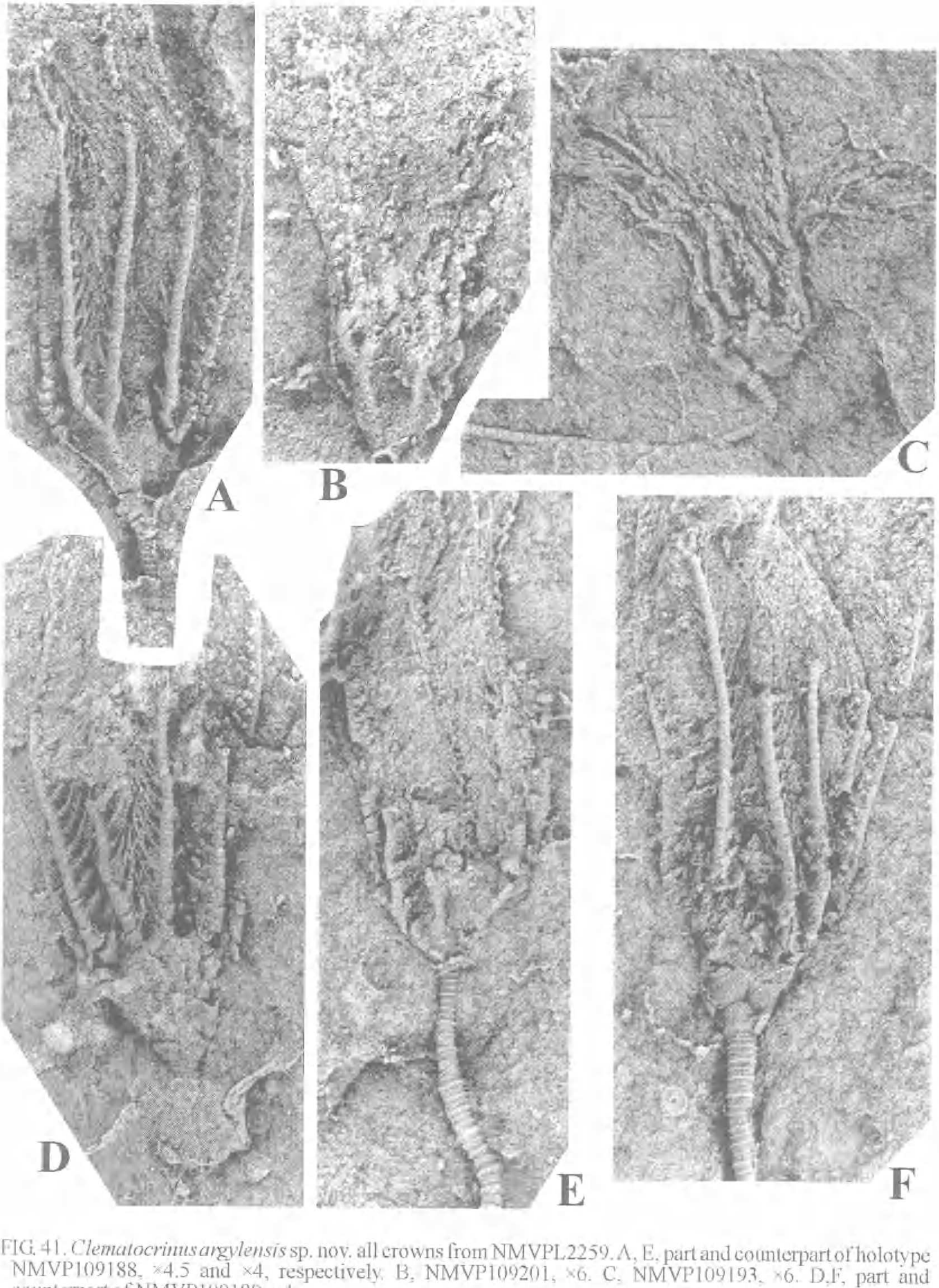


FIG. 41. *Clematocrinus argylensis* sp. nov. all crowns from NMVPL2259. A, E, part and counterpart of holotype NMVP109188, ×4.5 and ×4, respectively. B, NMVP109201, ×6. C, NMVP109193, ×6. D,F, part and counterpart of NMVP109189, ×4.

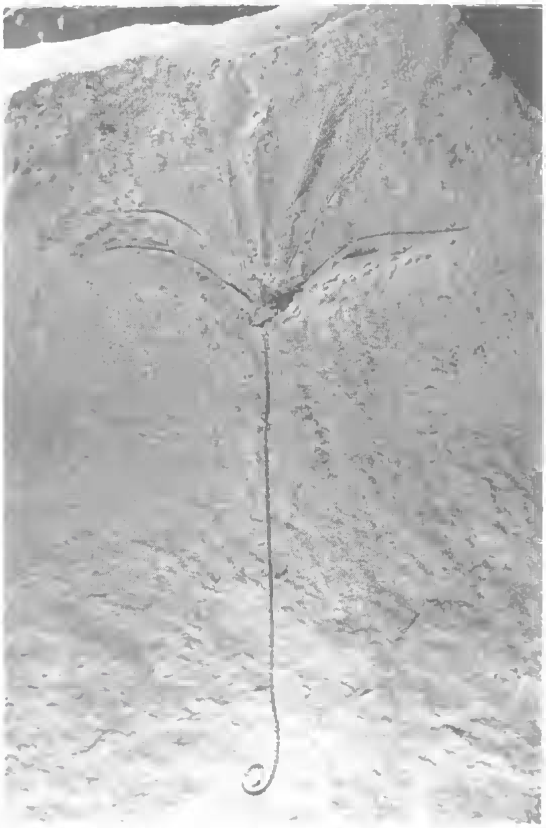


FIG. 42. *Helicocrinus plumosus* Chapman, 1903, holotype, NMVP384, from a quarry in West Brunswick Melbourne, ×1.7.

elongate anal tube; primanal central, pentagonal, smaller than proximal interbrachial of normal interrays, flanked by smaller anal tube plates in contact with primibrachs. Stem circular in section, heteromorphic: proximally with alternating nodals and internodals of similar length but with epifacets or annular flange at midlength of latus being wider on the nodals; distally with uniform columnals, each with the epifacet at midlength of latus.

REMARKS. This species is close to *C. perforatus* but has narrower radial facets and arms, different stem and longer unfused basal circlet.

Helicocrinus Chapman, 1903

TYPE SPECIES. *Helicocrinus plumosus* Chapman, 1903 from the Ludlow of Melbourne; by monotypy.

REMARKS. Ubaghs (1978b) suggested that this genus was 'Possibly a hapalocrinid' although placing it in the group of uncertain taxonomic placement. Chapman (1903) had noted the same alliance originally and no contrary opinion has been offered. The present state of the holotype and only specimen makes definite assignment impossible but the discussion of that specimen below gives confidence to a family assignment in the Hapalocrinidae. I recommend that since critical features of the holotype are not now retrievable the generic name should be confined to the holotype and isolated on that specimen. Although it may seem likely that *Clematocrinus perforatus* sp. nov. should belong to the same genus there is no proof of this and it is better not to compound the problem by extending use of such a poorly defined name. Nevertheless, occurrence of 5, and probably more, species of Hapalocrinidae in Victoria demonstrates that the family was successful in this region during the Late Silurian. *Helicocrinus* may be separated from known Hapalocrinidae by the distally coiled stem with pentagonal section.

Helicocrinus plumosus Chapman, 1903
(Fig. 42)

MATERIAL. HOLOTYPE: NMVP384 from a quarry at West Brunswick, between Albert and Victoria Streets. The matrix into which this individual was moulded is soft and friable; I have not made a latex cast because I consider it likely damage would be caused to the type.

REMARKS. Chapman (1903, pl. 18, figs 1-5) provided drawings of various parts of the holotype that are not clear from his photograph or from the holotype today. The holotype shows signs of having been damaged through efforts at preparation somewhere in the intervening 80 years since discovery but it may also be significant that in his description Chapman did not allude to any features of the cup plating. Even his drawing of the cup is incomplete just distal to the radials. Since the primibrachs are critical for species and genus recognition it is impossible to accommodate this specimen within current taxonomic concepts.

Hapalocrinidae indet.
(Fig. 43)

MATERIAL. NMVP107091 from the South Yarra Brickworks dump originally from excavations in the Ludlovian Melbourne Formation at the eastern end of Melbourne City area; collected by Leo Stach of Melbourne High School.

REMARKS. This 28mm long crown is preserved in a medium to coarse micaceous sandstone so that interplate sutures are not clear anywhere on the specimen. However, the cup is high conical

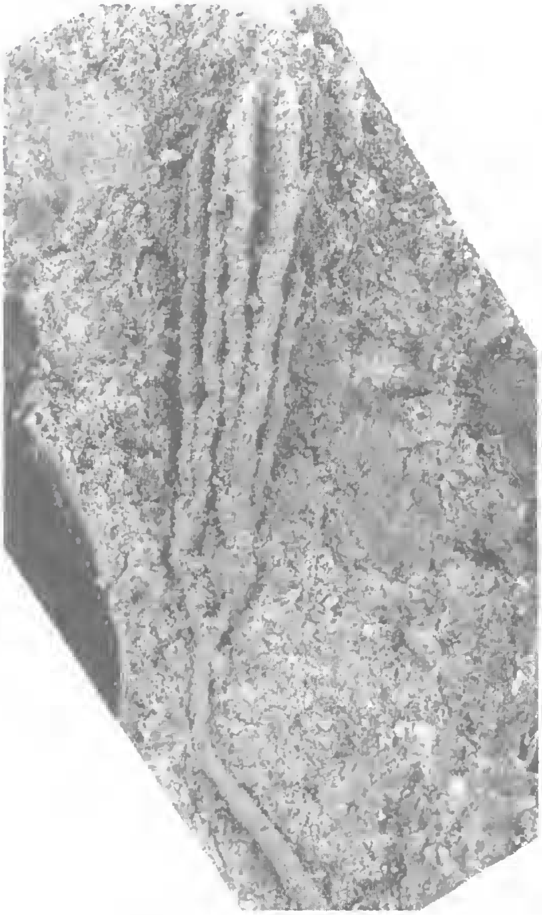


FIG. 43. Hapalocrinidae indet., posterior view of crown NMVP107091 from the South Yarra Brickworks Dump originally from excavations at the eastern end of Melbourne CBD, ×3.

and the general impression of radials and basals is discernible with a vertical (anal) tube beginning above the radials and extending up between the arms. There are 10 pinnulate arms; details of the stem are unclear except that there appear to be circlets of tubercles and some perforations distally. This meagre combination of features allows the specimen to be interpreted as a posterior view of a hapalocrinitid but generic determination appears impossible.

Subclass DISPARIDA Moore & Laudon, 1943
Superfamily CALCEOCRINOIDEA Meek & Worthen, 1869
Family CALCEOCRINIDAE Meek & Worthen, 1869

Darraghcrinus gen. nov.

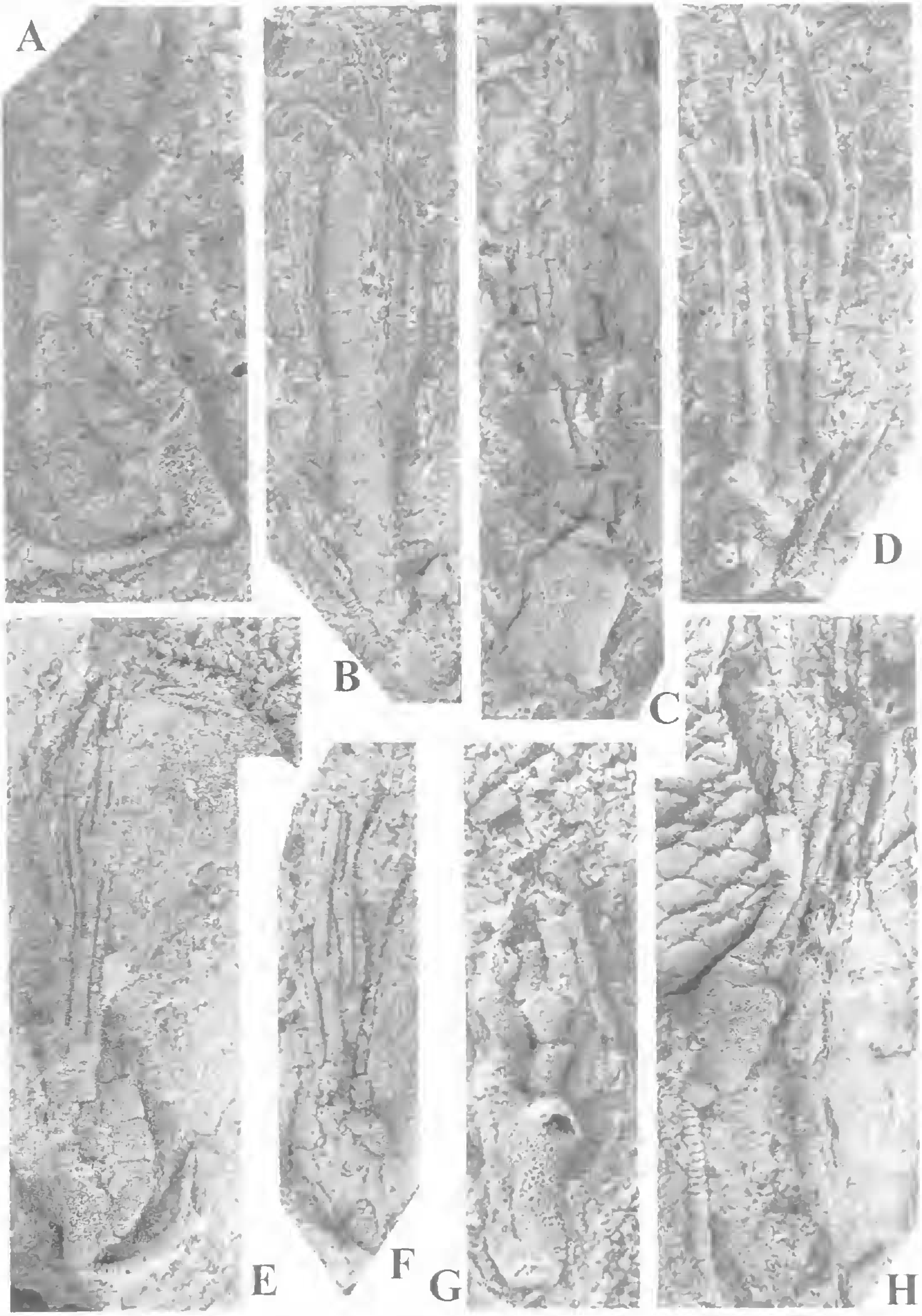
TYPE SPECIES. *Darraghcrinus tomi* sp. nov.

ETYMOLOGY. For Tom Darragh of the Museum of Victoria.

DIAGNOSIS. Cup elongate, waisted near mid-length, bilaterally symmetrical; E radial divided into small triangular supero- and inferoradials separated by long suture separating large lateral A and D radials; basal circlet semi-elliptical, of 3 plates, with two tiny plates and large triangular posterior plate, with stem attachment in contact with all 3 plates. E ray arm with or without a single division at primibrach 13; lateral arms with axillary 2nd primibrach, with subsequent isotomous divisions on both resulting branches (ramules and main axil series not evident).

DISCUSSION. Moore (1962) reviewed the phylogeny of the Calceocrinidae indicating 2 Ordovician to Devonian lineages distinguished by the degree of symmetry of the crown and his phylogeny has largely been accepted by subsequent workers (Arendt, 1965; Prokop, 1970). Since this Australian species has perfect bilateral symmetry it must belong to Moore's group arising from *Calceocrinus*. However, Moore (1962) also indicated the trend in this group towards development of main axils with ramules. In the Australian species main axils are not developed; A and D radials each support a lateral arm that divides isotomously twice, indicating that neither of the 2 branches from the first division can be considered a ramule. These features are sufficient to isolate the Australian species at generic level and to throw into doubt its possible affinities. The cup of *D. tomi* is very similar to that of *Eohalysiocrinus* Prokop, 1970 from the Devonian of Bohemia. Prokop (1970) did not figure specimens with arms but nevertheless provided a reconstruction with a single lateral arm on the A radial (and presumably another, not seen, on the D radial) that branches on the 2nd primibrach and then each branches again on the 3rd secundibrach; he identified primaxil and

FIG. 44. *Darraghcrinus tomi* gen. et sp. nov., all crowns from NMVPL252. A, lateral view of NMVP108653, ×4. B,D, part and counterpart of NMVP110637, ×3. C, E ray view of NMVP110635, ×4. E,F, part and counterpart of NMVP108654, ×4. G, D ray view of NMVP110640, ×7.5. H, oblique E ray view of NMVP108625, ×5.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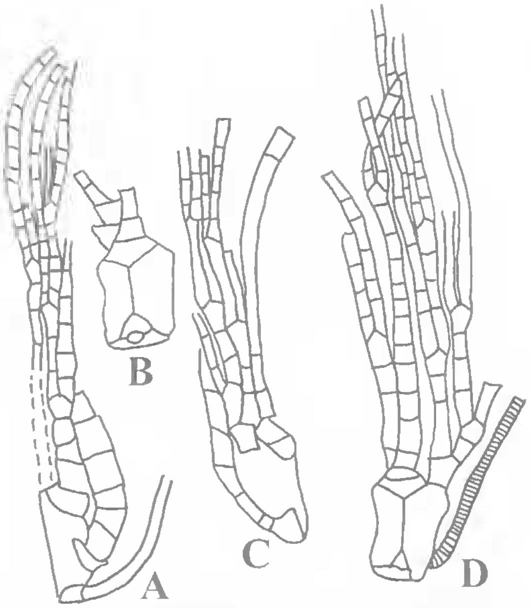


FIG. 45. *Darraghcrinus tomi* gen. et sp. nov., sketches of plate arrangement of A, NMVP108654a (Fig. 44E); B, NMVP110635 (Fig. 44C); C, NMVP108654b (Fig. 44F); D, NMVP110637a (Fig. 44D).

secundaxil arms and a ramule. While this branching pattern has some similarity with *D. tomi* there are distinct differences: branches after divisions in *D. tomi* are of equal diameter, the primibrach is much longer and narrower in *D. tomi* and the E ray arm is of similar diameter to the lateral arms. Brett (1981) indicated that Prokop's reconstruction of the arms is 'completely hypothetical' and showed an advanced arm branching pattern with main axil structure in *Eohalysiocrinus typus* from the Silurian of North America. Nevertheless, the cup of *E. typus* is very similar to that of *D. tomi* in observable features, particularly on the anterior side. Notably, however, Brett's species has a different arm branching pattern, anal tube completely enclosed by the arms and E ray brachials much larger than those of the lateral arms.

In the context of Moore's phylogeny *D. tomi* cannot be easily linked to any of the known Devonian members of the family. Its arm branching pattern seems akin to the most primitive members of the family or even the ancestral group, yet its cup resembles some of the most advanced Devonian taxa. I assign this genus to the Calceocrinidae with confidence but cannot suggest a reasonable ancestral lineage from among known forms.

Darraghcrinus tomi sp. nov.
(Figs 44-46)

MATERIAL. HOLOTYPE: NMVP149347. PARATYPES: NMVP108625, 108651, 108653, 108654, 108656, 110634, 110635, 110637-110640, 149363 from NMVPL252.

DIAGNOSIS. As for genus.

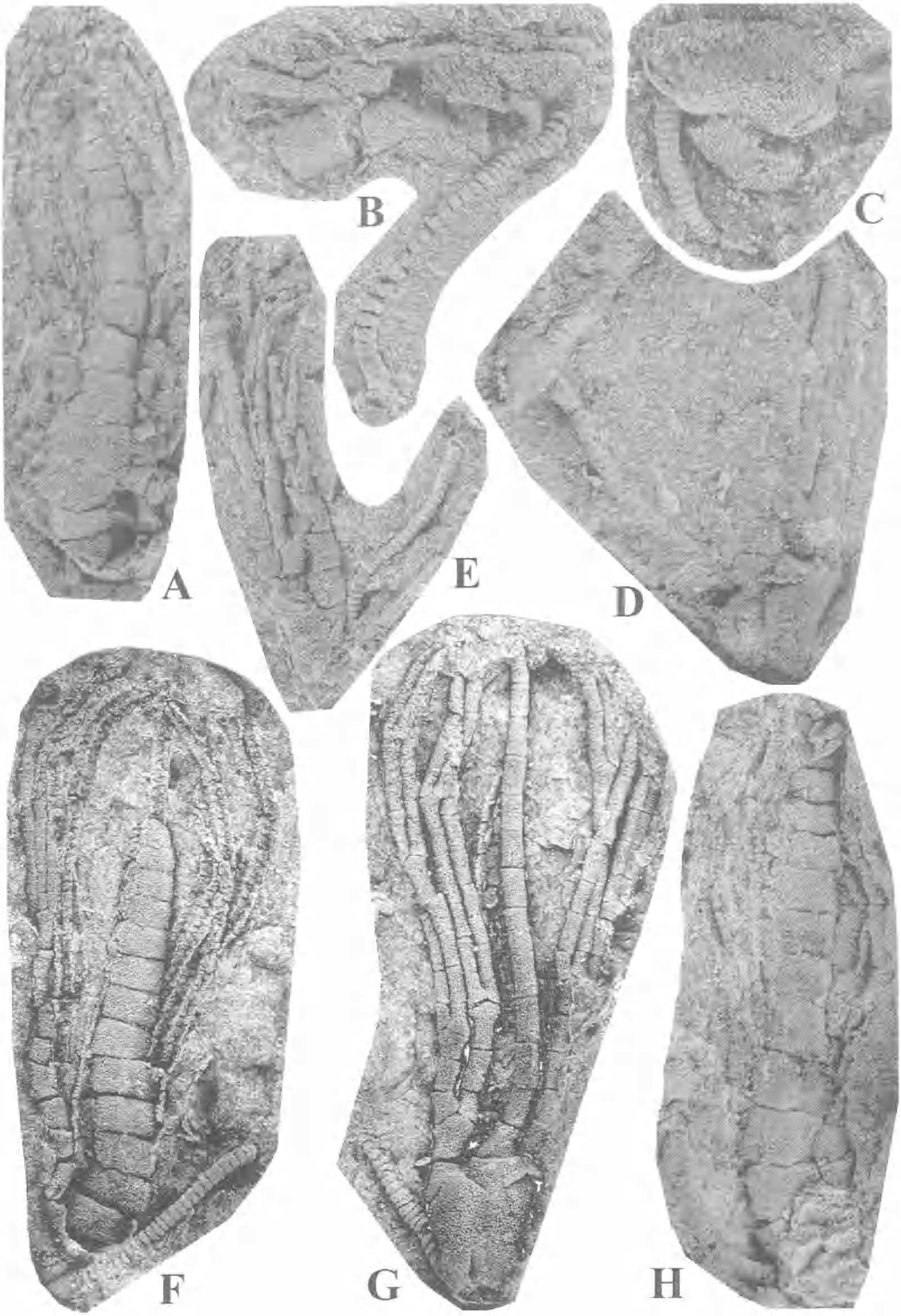
DESCRIPTION. Crown up to 36mm long. Calyx subrectangular in E ray view (c. 20% longer than wide), slightly waisted near midheight; E ray side of cup flat to weakly concave, opposite (posterior) side convex. Plates with finely granulose surface, with stereom structure of plates clear in most specimens.

Basal circlet not clear in any one specimen but inferred from parts of several; semi-elliptical, 3 plates, stem attachment straddling suture between two larger ones, third triangular much wider than long and occupying most of circlet.

E ray (median) inferoradial and superoradial widely separated by A and D radials; separation distance more than 1/2 cup height. Small, triangular E-ray inferoradial occupying just over 1/3 basal cup width; lower margin with a rectangular ligament fossa, bounded on each side by dentate projections of inferoradial. E-ray superoradial also triangular, 3 times as broad as long, extending above the A and D radials; radial facet broad, nearly circular.

Lateral (A and D) radials very large, enclosing cup laterally, extending onto posterior side; subanal plate (fused B and C radials) low, wide, only slightly recessed for anal X; anal X large, identical to more distal anal plates, bounded laterally by A and D radials and subanal, with rounded lower corners, occupying most of posterior side of cup. Anal tube projecting posteriorly from cup, curving anteriorly upwards to be enveloped by the lateral arms above midheight, of large laterally convex rectangular plates on posterior side, tapering slightly in upper half, rounded upper end, with anterior side of lower subrectangular plates.

FIG. 46. *Darraghcrinus tomi* gen. et sp. nov., all crowns from NMVPL252. A, lateral view of NMVP110639, ×4.7. B, lateral view of damaged cup with stem NMVP108651, ×4.7. C, small theca with stem NMVP108653b, ×5.7. D,E, part and counterpart of crown attached to large *Sphenothallus* NMVP110638a and B, ×3.3. F,G, lateral views of part and counterpart of holotype NMVP149347, ×4.7. H, lateral view of NMVP110634, ×5.7.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Arms 3; E-ray arm branching isotomously once high above cup, with 12 primibrachs, 12th axillary; 1st primibrach subtrapezoidal, tapering distally; rest of arm more or less uniform in section; interplate sutures poorly defined. A and D radials with 2 primibrachs, 2nd axillary; on more anterior branch 3rd or 4th secundibrach axillary, with 4th or 5th tertibrach axillary above that on posterior branch and with anterior branch undivided; on posterior branch of original division 2nd secundibrach axillary on posterior branch and 3rd or 4th tertibrach on anterior division axillary, then 4th quartibrach axillary on posterior branch (Fig. 44D); each arm tapering near base but mostly of uniform diameter.

Stem circular in section, of short laterally convex columnals, with columnals becoming slightly longer and less convex laterally away from cup; attachment simple cementation, observed in two cases to be cemented to large specimen of *Sphenothallus*.

Superfamily PISOCRINOIDEA Angelin, 1878
Family PISOCRINIDAE Angelin, 1878

Trichocrinus Müller, 1856

TYPE SPECIES. *Trichocrinus altus* Müller, 1856 from the Middle Devonian of Germany; by monotypy.

REMARKS. Moore et al. (1978) considered *Trichocrinus* a junior synonym of *Triacrinus* Munster, 1939 from the Late Silurian and Devonian of Europe. Rozhnov (1981) separated them and characterised *Trichocrinus* as having a longer, regularly conical, cup of smaller diameter as opposed to convex-conical shape with lobate profile in distal view, a shallow or no basal concavity for stem facet and a 'different form of distal growth'.

Rozhnov (1981, fig. 9) also provided a phylogeny showing *Triacrinus* and *Trichocrinus* evolving from different subgenera of *Pisocrinus*. I accept Rozhnov's generic concepts and phylogeny and assign this Victorian species to *Trichocrinus* with its tall conical cup lacking basal concavity. *T. morleyi* from the Ludlow is among the oldest known species of the genus and greatly extends its geographical range. Its occurrence in Australia may be significant in view of the Upper Devonian, Western Australian *Jaekelicrinus* (Jell & Jell, 1999) which genus belongs to the same lineage as *Trichocrinus*.

Trichocrinus morleyi sp. nov.
(Figs 47, 48)

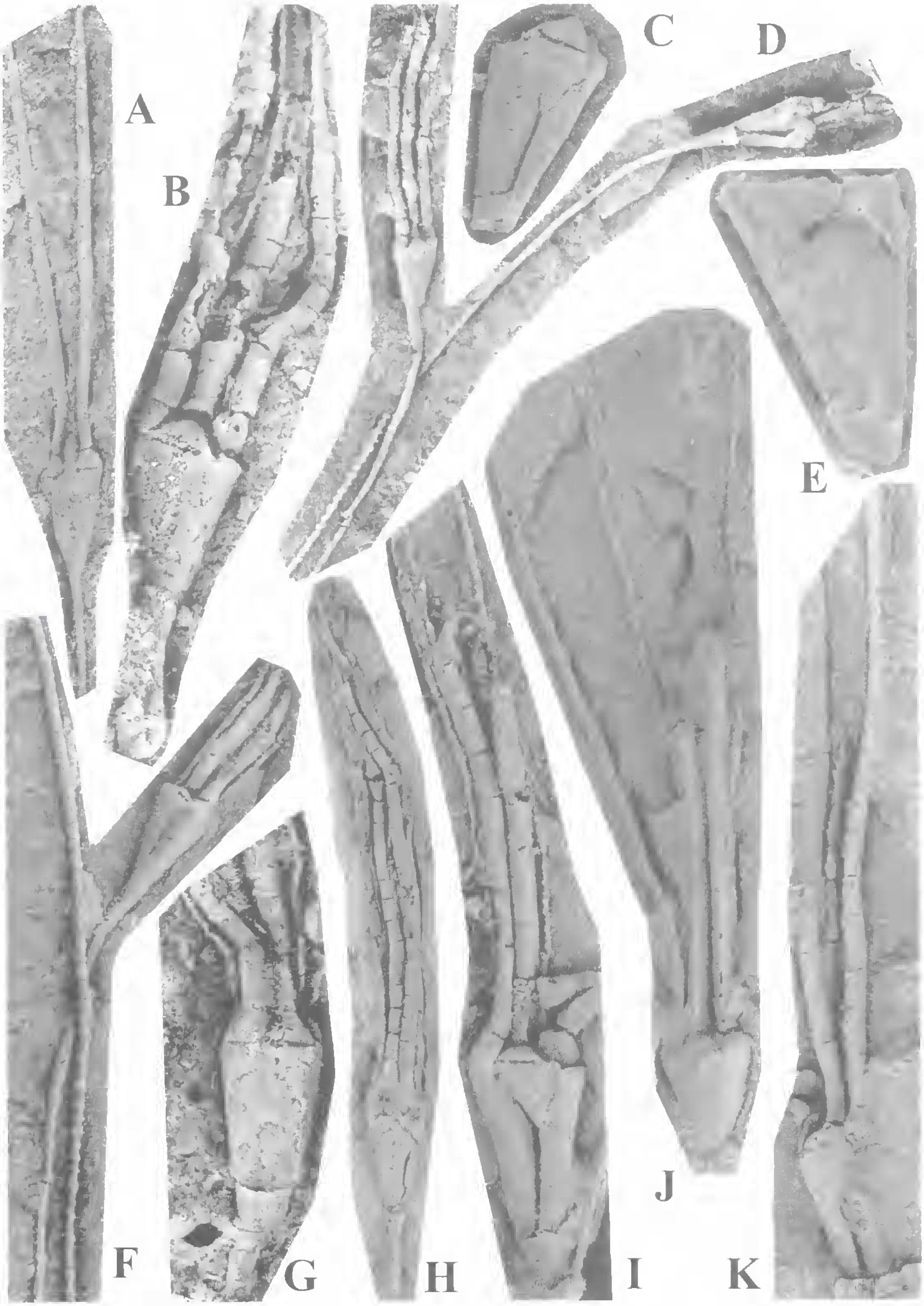
ETYMOLOGY. For David Morley who drew my attention to the occurrence of crinoids at the type locality.

MATERIAL. HOLOTYPE: NMVP100111. PARATYPES: NMVP100103, 100105, 100110, 100113-100115, 107108-107110, 109827 all from NMVPL1923. NMVP148608, 148611, 148612 from Moonee Ponds Creek; NMVP111845, 148624 from NMVPL299; NMVP391 from NMVPL1615.

DIAGNOSIS Cup with 3 basals, long, with rounded distal margin to inferradial. First primibrach short, tapering upwards. Arms 5, atomous, of long brachials, 5-10 times length of cup. Stem long, heteromorphic, of alternating columnals proximally becoming strongly beaded distally.

DESCRIPTION Crown small, with very long arms up to 10 times as long as cup. Cup approximately twice as long as wide, smooth. Basals 3, forming circlet only marginally wider than long. Radials smooth, with A and D radials more than twice as long as wide, with E radial small triangular and taking part of distal corner from both A and D radials (more from D than A); B superradial and C radial approximately same size as E radial but apparently with concave proximal margin; B inferradial large, with rounded distal margin, rotated to right (theca oriented with stem down) i.e. anticlockwise relative to superradial; all radials with vertical grooves on both plates at and normal to the radial to 1st primibrach suture. Anal X distal to cup, between the C and D primibrachs. Arms 5, atomous, 5-10 times as long as cup, nonpinnulate, laterally compressed, with deep adoral groove covered by 2 series of interlocking cover plates; 1st brachial subtriangular, with broad base on radial facet, lower than more distal brachials, twice as wide proximally as distally; other brachials more than twice as long as wide, of approximately uniform length through arm, with 8 pairs of adoral groove cover plates in contact with each brachial. Stem long but full extent not known, circular in section; columnals uniform in length proximally

FIG. 47. *Trichocrinus morleyi* sp. nov. all crowns in lateral view except for one cup (C and E) from NMVP1923. A, NMVP100103, ×3.5. B,G, part and counterpart of holotype NMVP100111, ×4.5. C,E, part and counterpart of NMVP100110, ×4.5 and ×7. D,F, NMVP100113 (to right in D) and part and counterpart of NMVP100114, ×3 and ×4.5, respectively. H, NMVP100115, ×3. I, NMVP107110, ×4.5. J, NMVP107108, ×4. K, NMVP107109, ×5.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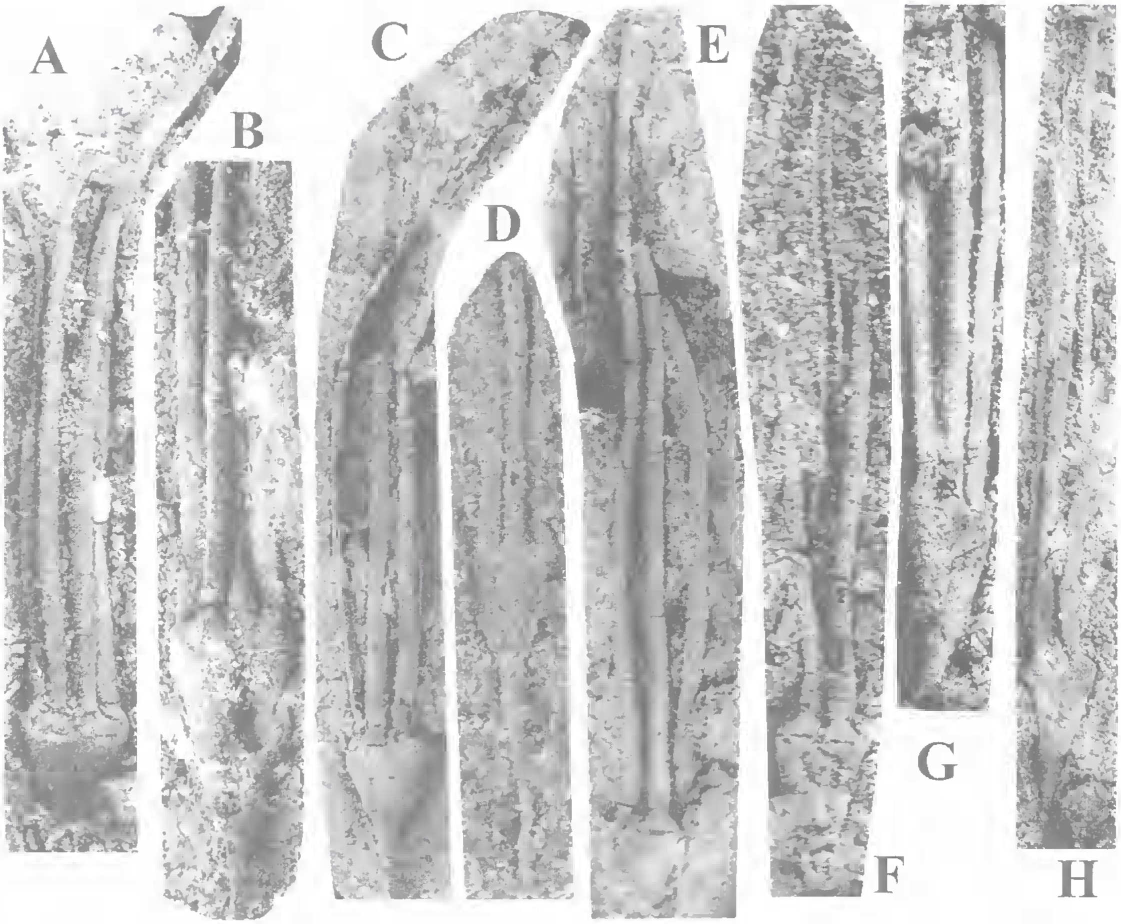


FIG. 48. *Trichocrinus morleyi* sp. nov., all crowns in lateral view. A,B, part and counterpart of NMVP148608 from Moonee Ponds Creek, ×3. C,E, part and counterpart of NMVP148624 from NMVPL299, ×3. D, NMVP111845, ×4. F, NMVP391 from NMVPL1615 (with type of *Nassoviocrinus longibrachiatus*), ×3. G, NMVP148612 from Moonee Ponds Creek, ×4. H, NMVP148611 from Moonee Ponds Creek, ×3.

but alternating long and short distally, diameter decreasing uniformly and rapidly through 10 most proximal, then uniform for variable distance of between 30-200 columnals, then alternating large and small to give a beaded appearance to most of stem.

REMARKS. This species is closely related to *T. elongatus* Follmann, 1887 and *T. altus* Muller from the Lower Devonian Hunsrück Shale of Germany but differs in its shorter arms with longer more uniform brachials, its longer basals, rounder distal margin to the B inferradial, and more noticeably beaded distal stem. Several species of *Pisocrinus* grouped by Rhozhnov (1981) as *P. (Pocillocrinus)* and exemplified by *P. (P.) pocillum* Angelin, 1878 from the Late Silurian of Gotland have similarly shaped cups as remarked by Bather (1893:23), are part of a lineage among long species from 5 basals to 3 and prompt the question of whether the number of basal plates is a watertight generic distinction. Since the same reduction occurs in other groups (e.g. the Synbathocrinidae — *Phimocrinus* to *Synbathocrinus*) it is clear that numerous lineages involved reduction in numbers of basals. Since Rozhnov (1981) identified the separate lineages leading from *Pisocrinus* to forms with 3 basals the question now arises whether he has identified all the lineages in the family or did the 5 to 3 basals transition occur more than twice in the Pisocrinidae? Could there have been a separate lineage in Australia evolving in parallel

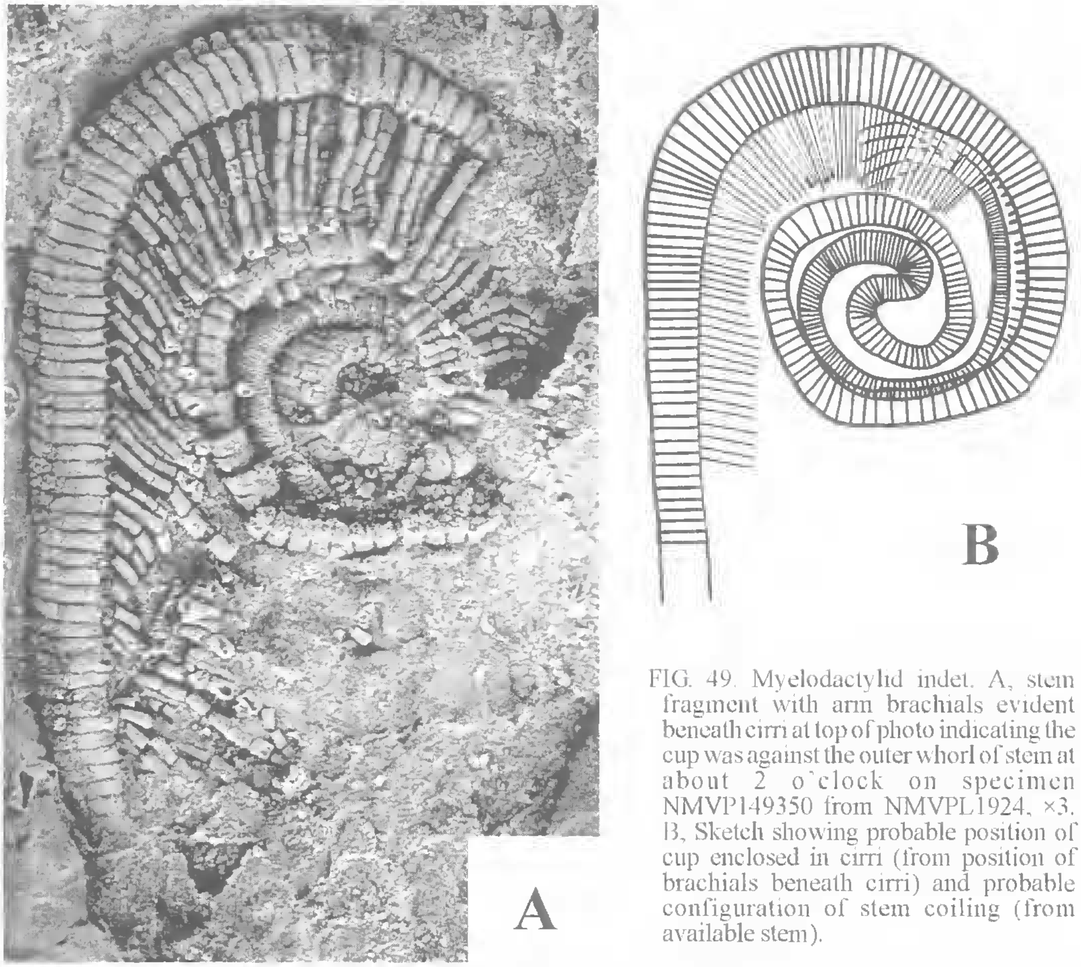


FIG. 49. Myelodactylid indet. A, stem fragment with arm brachials evident beneath cirri at top of photo indicating the cup was against the outer whorl of stem at about 2 o'clock on specimen NMVP149350 from NMVPL1924, ×3. B, Sketch showing probable position of cup enclosed in cirri (from position of brachials beneath cirri) and probable configuration of stem coiling (from available stem).

to the European lineages outlined by Rozhnov (1981) or, as seems most likely at present, did the Australian pisocrinids migrate iteratively from Eurasia during the Ludlow, and the Upper Devonian?

Several specimens (Fig. 48) assigned to this species from other than the type locality are preserved in medium to coarse sandstone; in these, details of plate boundaries are not always clear so assignment is made on cup shape, on length of arms and on the anal X above the cup.

Superfamily MYELODACTYLOIDEA S.A. Miller, 1883
Family MYELODACTYLIDAE Miller, 1883

Myelodactylid indet.
(Fig. 49)

MATERIAL. NMVP149350 from NMVPL1924.

DESCRIPTION. Proximal or evolute part of stem composed of many short columnals compressed in the plane of coiling and with a shallow narrow groove along the curved visible edge of the stem. Midsection or 2 inner involute whorls with longest columnals of whole stem, also compressed in the plane of coiling, with stout cirri on each columnal. Distal section or outer involute whorl apparently less compressed, stongly convex on outer side with groove on side (presumably one on other side as well) of central peak, with long cirri on each columnal.

REMARKS. Details of members of this family are available from a number of taxa well-preserved as original carbonate (Bather, 1893; Springer, 1926) with crowns well displayed. In the available Victorian external mould the crown is indicated by a number of arms beneath the cirri of the outer whorl; taking this indication with the direction of the proximal stem the crown is inferred to have been adjacent to the outer whorl about 3/4 of the way around. Without the crown I do not attempt generic assignment as advocated by Eckert & Brett (1985) but the strongly coiled stem with differentiated proximal part, strong development of cirri, and indicated position of the crown all confirm the family assignment. The specimen is included here as an indication of the family's occurrence in Australia and warning to future collectors to seek out this interesting but relatively rare group of crinoids.

Superfamily BELEMNOCRINOIDEA S.A. Miller, 1883

This superfamily as constituted by Moore et al. (1978) is a heterogeneous grouping of widely differing, mostly very small, crinoids whose affinities are often unclear. Rozhnov (1981) reassigned *Quiniocrinus* Schmidt, 1941 from the Perissocrinidae to the Pisocrinidae and Prokop & Petr (1997) suggested that *Storthingocrinus* is a camerate related to the Platycrinitidae; reassignment of other taxa grouped in this superfamily in 1978 seems likely.

Family PYGMAEOCRINIDAE Strimple, 1963

This family is monotypic and has been reviewed in detail by Prokop & Petr (1997). The new genus described here initially looks quite different from the Czech type species but comparison with Prokop & Petr's (1997) emended diagnosis reveals that the only difference between Czech and Australian taxa is in the number of brachials in each arm. *Pygmaeocrinus* Bouska, 1947 must be considered a derived form in the structure of its arms which consist of just 2 brachials, a small 1st and large widened 2nd that fully enclose the cup distally and *Kroppocrinus* can be considered a reasonable intermediate from a synbathocrinid like *Phimacrinus hanschi* sp. nov. which has 5 basals and an anal plate almost expelled from the cup. *Kroppocrinus* has the 5 basals but fewer brachials per arm and no anal plate. Thus I suggest that as a probable ancestor this new genus should be placed in the Pygmaeocrinidae.

Kroppocrinus gen. nov.

TYPE SPECIES. *Kroppocrinus heathcotensis* sp. nov.

ETYMOLOGY. An anagram from Prokop plus the usual ending *-crinus*; for Rudi Prokop, Prague who has contributed to knowledge of Bohemian echinoderms.

DIAGNOSIS. Crown more than 3 times as long as cup. Arms in close lateral contact forming a tall conical enclosed space, with 5 or 6 brachials; 1st small, subquadrate, set into outer notch of radial facet; 2nd very large, up to 4 times as long as wide, with widest point above upper limit of radial's interradial peak, with series of horizontal ridges laterally on inner side; more distal brachials less than half as long as 2nd, of different lengths in different arms. Stem either attached to

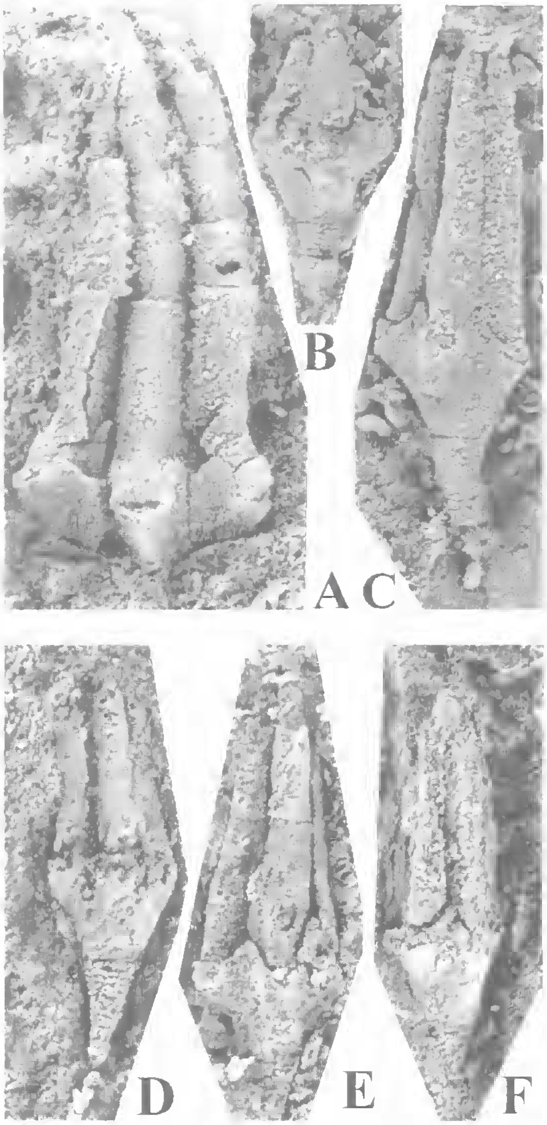


FIG. 50. *Kroppocrinus heathcotensis* gen. et sp. nov., all crowns in lateral view from locality 36 of Talent (1965, fig. 1) at Heathcote except A from NMVPL229. A, NMVP107106, ×6. B, NMVP-107093, ×7. C,E, part and counterpart of holotype NMVP107094, ×10. D,F, NMVP107092, ×9.

rimmed facet in centre of flat cup base or same diameter as cup base but tapering rapidly distally; in latter case columnals low, uniform proximally becoming longer and heteromophic distally.

REMARKS. These 2 species are quite different in the size of the stem relative to the cup proximally and recessed basals laterally on cup on one but not other. However, cup shape and details of the arms are so similar that they are confidently assigned to the same genus herein. *K. mathiesonensis* has cup features linking it to *Pygmaeocrinus notabilis* Prokop & Petr, 1997 namely, the flat cup base with small rimmed stem attachment facet, depressed triangular distal extremities of the basals in view laterally and shape and projection of radials; however, it is the only specimen available and it has one branching 2nd brachial making it probably an aberrant specimen and therefore, unsuitable for type genus status. *K. heathcotensis* has less distinctive link to *Pygmaeocrinus* having a similar cup shape to *P. fabulosus* Prokop & Petr, 1997 but without unique characters. Nevertheless, it is a far more suitable species to stand as type since it is represented by several specimens and has the atomous arms considered typical of the genus.

Kroppocrinus heathcotensis sp. nov.
(Fig. 50)

ETYMOLOGY. From near Heathcote, central Victoria.

MATERIAL. HOLOTYPE: NMVP107094. PARATYPES: NMVP107092, 107093 all from Locality 36 of Thomas (Talent, 1965, fig. 1); paratype NMVP148560 from locality 41 of Thomas (Talent, 1965, fig. 1); paratype NMVP107106 from NMVPL229.

DIAGNOSIS. Cup evenly flaring in proximal part, same diameter as stem at their junction, with concave lateral cup margin due to extended radial facets.

DESCRIPTION. Crown bipyramidal, pentalobate in section through radials or more distal, up to 12mm long. Cup 2-4mm long and wide, flaring uniformly distally in basal part but increasing in distal part of radials producing concave outer profile. Basals 5, circlet occupying about 1/4 cup length, not well defined, with low obtuse peaks at interradial sutures. Radials 5, subrectangular, longer than wide, expanding strongly laterally to facet, with sharply pointed interray peaks; radial facet deep narrow notch, slightly declined outwards. Arms 5, atomous, in lateral contact throughout forming tightly closed space within, with horizontal ridges laterally on inner surface of brachials interlocking with adjacent brachials; brachials 5 per arm; 1st short; 2nd very long; distal ones of variable lengths within and between arms so adjacent arms may have distal interbracial articulations at different levels. Stem same diameter as base of cup at attachment; proximal part tapering strongly, of very short columnals of uniform length; distally heteromorphic, slightly wider and longer nodals alternating with very short internodals.

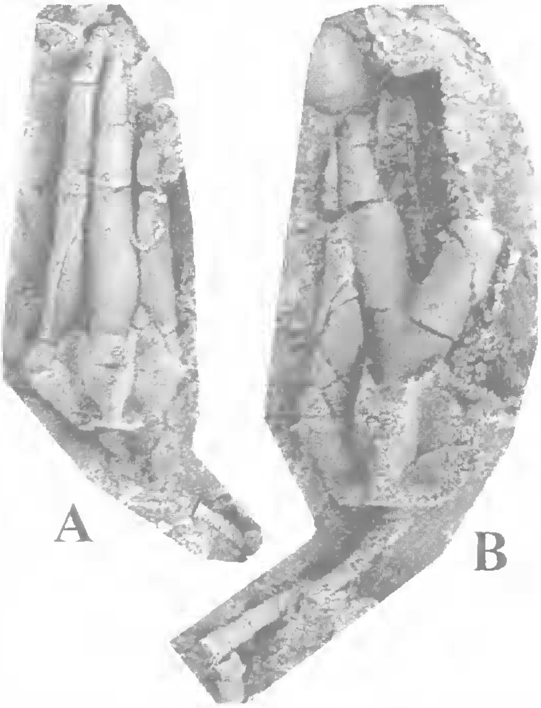


FIG. 51. *Kroppocrinus mathiesonensis* gen. et sp. nov., part and counterpart of holotype crown NMVP109752 from NMVPL1924, ×4 and ×6 respectively.

REMARKS. This species is distinguished from *K. mathiesonensis* by nature of cup base and nature of stem. The available specimens have some hardened limonitic infills in the moulds which result in the slightly incomplete latexes illustrated but taken in combination available specimens provide a clear species concept. Although not figured, features of distal parts of the stem are available on NMVP148560.

Kroppocrinus mathiesonensis sp. nov.
(Fig. 51)

ETYMOLOGY. From Mathieson's Creek, near Kinglake.

MATERIAL. HOLOTYPE: NMVP109752 from NMVPL1924.

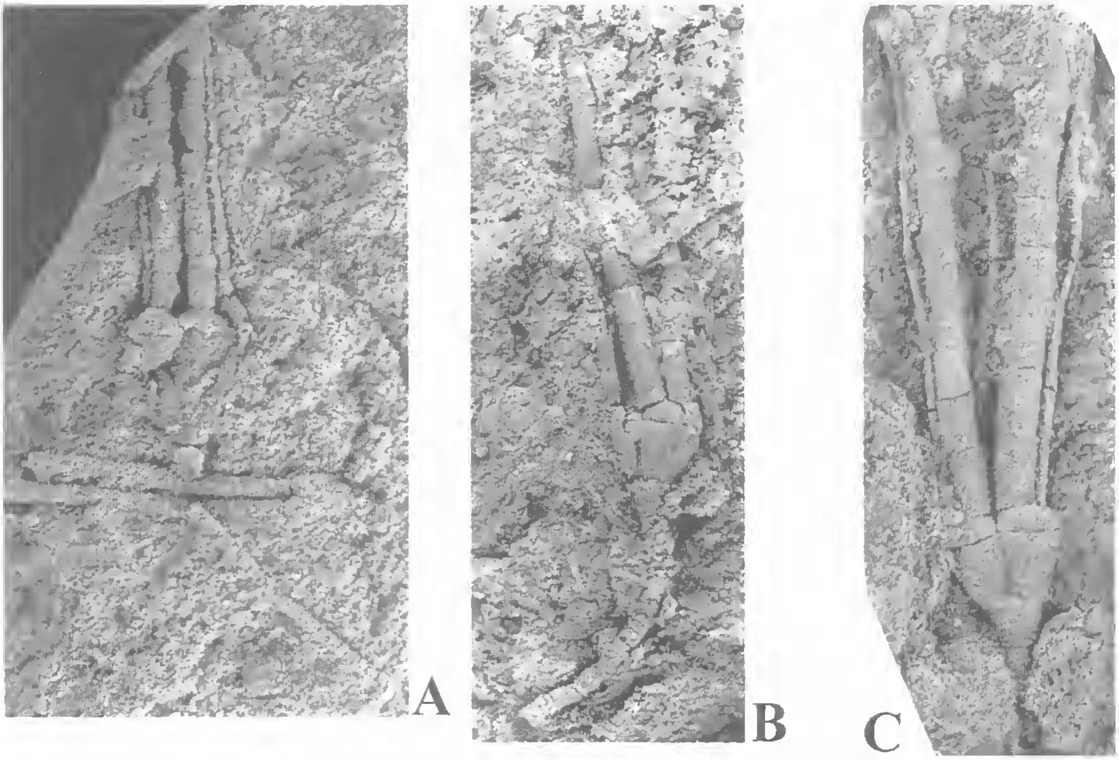


FIG. 52. *Phimocrinus americanus* Springer, 1923, all crowns in lateral view. A, NMVP109206 from NMVPL1615, ×5. B, NMVP100151 from NMVPL229, ×3. C, NMVP109205 from NMVPL229, ×4.

DIAGNOSIS. Cup with flat base, much greater in basal diameter than proximal stem, with straight distally flaring outer wall. Basals as depressed interradial triangles in lateral view extending distally from cup base.

DESCRIPTION. Crown bipyramidal, pentastellate in section through radials or more distal, up to 7mm long. Cup 2mm long and wide, flaring uniformly distally giving straight outer profile. Basals 5, occupying most of flat cup base and depressed triangles interradially in side walls of cup. Radials 5, subrectangular but with prominent, strongly constricted base between basals, longer than wide, expanding strongly in midline to facet, with sharply pointed interray peaks; radial facet deep narrow notch, declined outwards. Arms 5, atomous, in lateral contact throughout, forming tightly closed space within, with horizontal ridges laterally on inner surface of brachials interlocking with adjacent brachials. Brachials 5 per arm, 1st short, 2nd very long, distal ones of variable lengths within and between arms so adjacent arms may have distal interbracial articulations at different levels. Stem of much smaller diameter than cup base, of uniform diameter except for very small expansion towards cup in most proximal part; columnals uniform, short, separated by crenulate sutures.

REMARKS. The most obvious comment on this specimen has to be on the bifurcate arm (Fig. 51B). In view of the related type species *K. heathcotensis* having its arms tightly closed and the other 4 arms of this specimen appearing the same, this bifurcate arm is here considered aberrant, probably the result of damage and regrowth. How the animal lived without being able to seal the space within the arms is not clear because that seems to have been a functional requirement of this group of crinoids, judging from other available material. I have not, therefore, included this in features of the species even though I do not have available a specimen to prove that this is an aberrant specimen.

Family SYNBATHOCRINIDAE
S.A. Miller, 1883

Phimocrinus Schultze, 1867

TYPE SPECIES. *Phimocrinus laevis* Schultze, 1867 from the Middle Devonian of Germany.

REMARKS. This genus is separated from *Synbathocrinus* principally on its 5 rather than 3 basal plates. However, some species of the latter genus have the basals fused so this feature is not clear cut. The 2 Australian species described here have much longer brachials than in any *Synbathocrinus* where the brachials are usually wider than long or subquadrate in lateral view; in the absence of arms for the European species this feature cannot be applied universally.

Phimocrinus americanus Springer, 1923
(Fig. 52)

MATERIAL. HOLOTYPE: Springer, 1923, pl. 5, figs 17-19 from the Lower Devonian Linden Formation in Benton County, Tennesee; NMVP100151, 109205 from NMVPL229; NMVP109206 from NMVPL1615.

DIAGNOSIS. Cup evenly tapering, high conical, of smooth plates. Anal X notched into tops of adjoining C and D radials. Arms long, of elongate brachials.

DESCRIPTION. Cup small, up to 4mm long, high conical, smooth. Basals 5, short, with obtuse upper angle at interradial sutures. Radials long, forming most of cup, almost twice as long as wide, with horizontal distal suture; articular facet full width of radial; 1st primibrach short, tapering distally, sloping inwards so that bases of 2nd primibrachs remain in contact laterally but around a circle of smaller diameter than that of radials. Arms 5, atomous, straight, (probably laterally in contact throughout life), with broad shallow ambulacral furrow, cuneate in section; brachials of variable length, with some twice as long as others. Anal X small, triangular, nestled between C and D radials distally; anal tube extending up inside arms, full extent unknown. Stem circular in section, diameter small in relation to cup, with nodals just larger and more prominent than internodals; length unknown.

REMARKS. The single North American specimen lacks arms and stem but is matched in every available feature of the cup by the Australian specimens. There is no basis to separate these specimens from different parts of the world but future discovery of a complete specimen in North America could necessitate a new specific name for the Australian material.

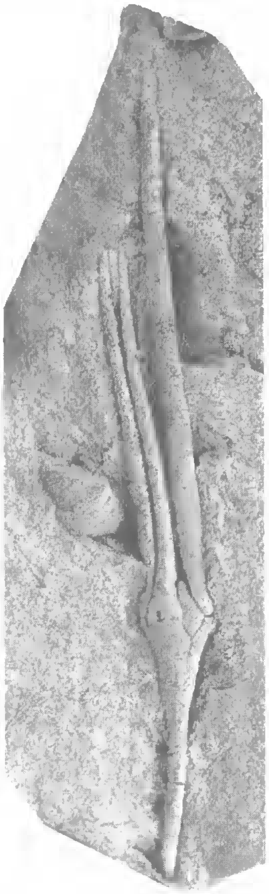


FIG. 53. *Phimocrinus hanschi* sp. nov., holotype crown in posterior view, NMVP100648 from NMVPL300, ×2.5.

Phimocrinus hanschi sp. nov.
(Fig. 53)

ETYMOLOGY. For David Hansch of Melbourne who contributed specimens to this study.

MATERIAL. HOLOTYPE: NMVP100648 from NMVPL300.

DIAGNOSIS. Cup high conical, slender. Anal X strongly notched into radials. Arms long, that of C ray longer than others, of long brachials. Stem circular in section, slender, heteromorphic, with nodals longer than internodals.

DESCRIPTION. Cup small, up to 4mm long, high conical, very slender, smooth. Basals 5, short, about 1/4 of cup length. Radials long,

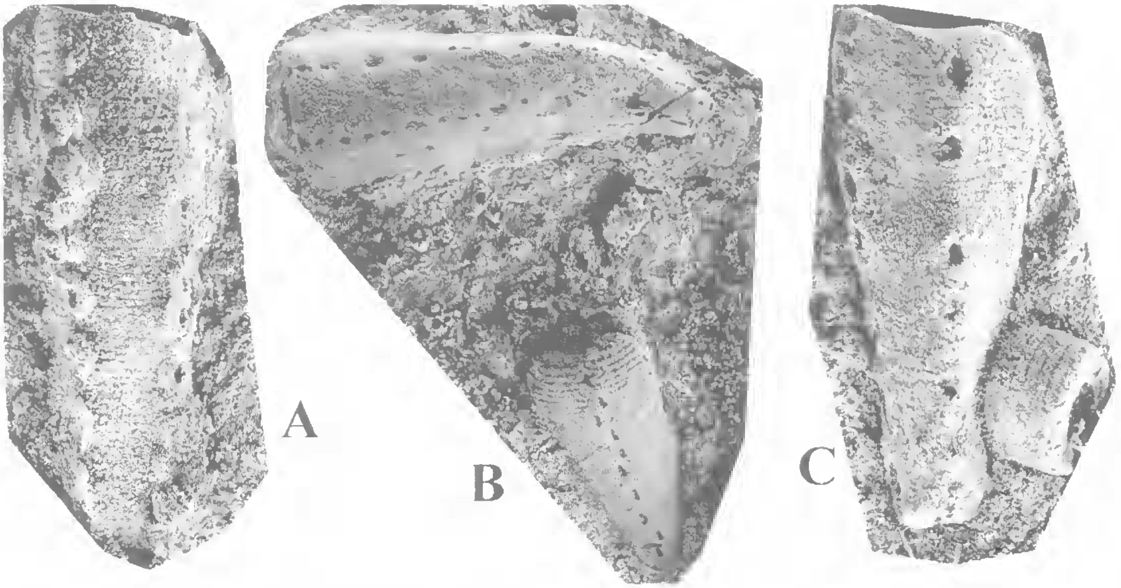


FIG. 54. *Crotalocrinites* sp., all distal stem elements of fused columnals with canals leading into cirri in 5 vertical columns from locality 54 of Talent (1965, fig. 1), ×1.2. A, NMVP149349. B, NMVP16789. C, NMVP149348.

forming most of cup, almost twice as long as wide, with straight distal suture; articular facet full width of radial, horizontal; 1st primibrach short, tapering distally and sloping inwards so that bases of 2nd primibrachs remain in contact laterally but around a circle of smaller diameter than that of radials. Arms 5, atomous, straight, (probably laterally in contact throughout life), with that in C ray about 1/3 again longer than other 4, with broad shallow ambulacral furrow, cuneate in section; brachials of variable length, with some twice as long as others. Anal X small, triangular, notched into distal corners of C and D radials; anal tube inside arms, full extent unknown. Stem circular in section, diameter small in relation to cup, with nodals just longer than internodals; length unknown.

REMARKS. In this species the basal part of the cup is very slender because the flaring of the cup occurs near the distal margins of the radials whereas in other species the cup flares near the base to be more bell-shaped. Arms are unknown for any Northern Hemisphere specimens so comparison is impossible but the elongate C ray arm distinguishes this species from *P. americanus* as interpreted from the Australian material described above.

Subclass CLADIDA Moore & Laudon, 1943
Order CYATHOCRINIDA Bather, 1899
Family CROTALOCRINITIDAE Bassler, 1938

Crotalocrinites Austin & Austin, 1843

TYPE SPECIES. *Cyathocrinites rugosus* Miller, 1821 from the Upper Silurian of England; by original designation.

Crotalocrinites sp. indet.
(Fig. 54)

MATERIAL. NMVP16789, 149348 and 149349 from locality 54 (Talent, 1965, fig. 1) in Unit 3 of the Mount Ida Formation, N of Heathcote.

REMARKS. These specimens are large (up to 20mm in diameter and 80mm long) disarticulated distal stem terminations. They are subpentagonal in section, have a line of perforations leading into stout cirri or rootlets along each angle and are ornamented with close spaced horizontal grooves arond the stem. This long section is almost certainly formed by fusion of numerous columnals with the horizontal grooves indicating the former columnal boundaries.

Distal stems of this type were described from the Silurian of the Urals by Militsina (1980, pl. 2, fig. 4; pl. 3, figs 3, 4) for *Crotalocrinites* and *Syndetocrinus* of the Crotalocrinitidae. The Russian material has a round rather than

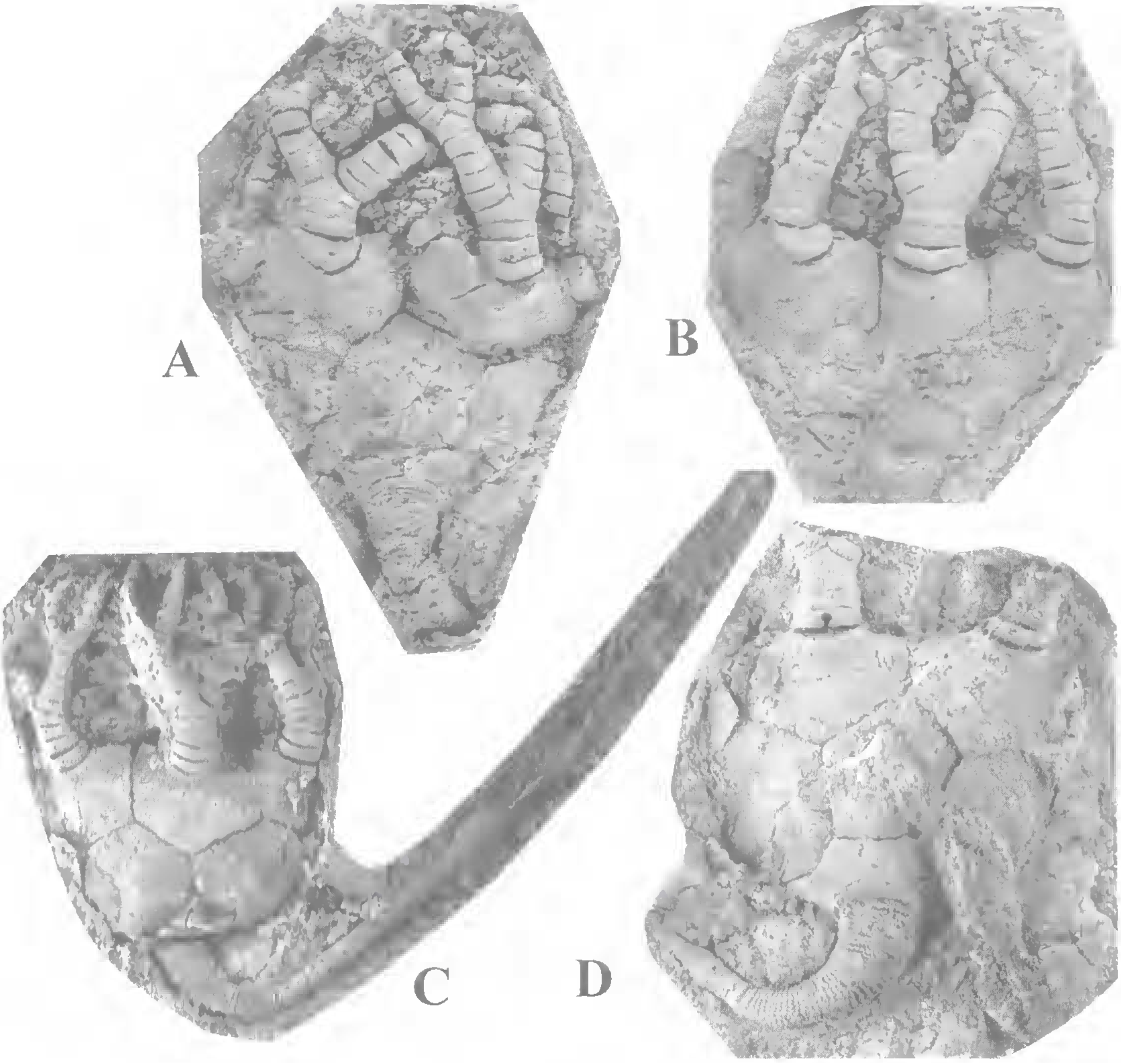


FIG. 55. *Codiacrinus secundus* sp. nov., all crowns in lateral view from NMVPL252. A,B, part and counterpart of NMVP108574, ×2.5. C, NMVP108576, ×2. D, NMVP108573, ×2.

subpentagonal section and the cirri are less regularly placed in *Crotalocrinites* and less nodular in *Syndetocrinus*. Nevertheless, there are striking resemblances in size, alignment of cirri in 5 vertical columns and external ornament of close-spaced horizontal grooves; on this basis it seems reasonable to make a family assignment. A crown of *Crotalocrinites pulcher* Hisinger, 1840 was recorded from the same rock unit in a white porous sandstone (Jell, 1982); it was collected from a gully where it had been placed by man and may have come from the same locality as these stem sections. On this basis I assign these distal stem segments to *Crotalocrinites* with the high probability that they belong to *C. pulcher*.

Family CODIACRINIDAE Bather, 1890

Codiacrinus Schultze, 1867

TYPE SPECIES. *Codiacrinus granulatus* Schultze, 1867 from the Eifelian of Germany near Prum; by original designation.

Codiacrinus secundus sp. nov.

(Figs 55, 56)

ETYMOLOGY. Latin *secundus*, second; the second species of the genus recognised in Victoria.

MATERIAL. HOLOTYPE: NMVP108570. PARATYPES: NMVP108573, 108574, 108576, 108578, 108580, 108660, 109208, 109209, 149364 all from NMVPL252.

DIAGNOSIS. Cup finely granulose, with only the faintest suggestion of median ray ridges; radial facet occupying 1/2 radial width; first branching variable – 2nd, 3rd, 4th or 5th primibrach axillary;or peaks on the midline of the brachials absent; 1st secundibrachs and tertibrachs sutured against each other just distal to peak of axillary; stem tapering in proximal part, of short columnals separated by highly crenulate sutures.

DESCRIPTION. Crown subelliptical, 40mm long. Cup probably (always found flattened) of medium length, globose, with convex base; infrabasals 3, 2 large and 1 small, about half length of basals, forming pentagonal base to cup. Basals pentagonal, largest plates in cup, with extremely faint low median ray ridges forming central prominence and apparently in high cross meeting proximal and distal sutures at right angles. Rradials pentagonal, with low ray ridges continuing from basals to meet at midwidth of radial facet; radial facet less than half width of radial, almost circular (small tangential sector missing on oral side), sloping down and out only very gently (compression prevents accurate assessment but least disrupted specimen suggests virtually no slope), flat surface except for extremely weak transverse ridge almost disappearing medially, with fine canal emerging near outermost point on margin, with slightly raised rim around margin. Arms branching isotomously at least 3 times probably more; primibrachs usually with 4th axillary, one ray (Fig. 56F, left) with 2 primibrachs, quite short (diameter more than twice length), with same barely discernible transverse ridge as radial facet, with angular (70°-90°) projections orally beside wide shallow adoral groove; secundibrachs 5-7; tertibrachs 5; with 1st brachials in each arm above a fork sutured against each other for all or most of their length, with low nodes developed on the aboral midline of many secondary and distal brachials, with brachials increasing in length relative to diameter up the arms, with distal parts of arms curved back axially. Stem with very short, wide, highly crenulate columnals at base of cup, with columnal length increasing and columnal diameter decreasing away from cup, with long columnals in distal part of stem bearing circlet of stout rootlets; distal end of stem not preserved.

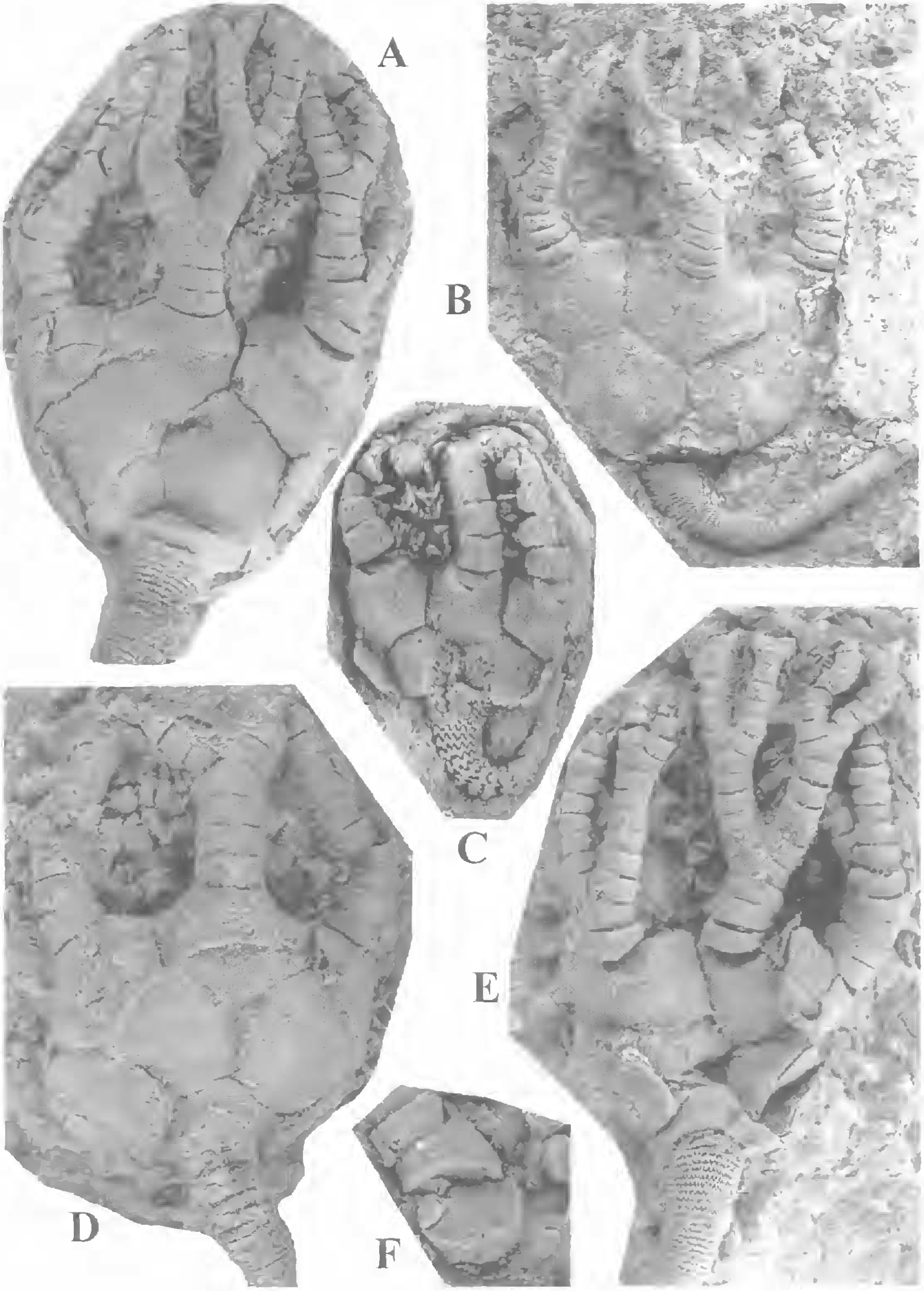
MORPHOGENY. One small individual (Fig. 56C) suggests that during growth the low ridges on cup plates became much less obvious, length of the basals increased relative to length of the radials from being less than in the small individual to being more than in large specimens, ratio of width to length of radials increased so making the cup more globose without introduction of new plates, and ratio of width to length of primibrachs and stem columnals increased dramatically.

REMARKS. This species is close to *C. schultzei* Follmann, 1887 from the Early Devonian Hunsrück Schiefer near Bundenbach, Germany, but is distinguished by its larger radial facets relative to size of radial plate, its variation in which primibrach is axillary, the suture between the 1st pair of brachials after an arm fork, by its nodes (if anything at all) rather than spines aborally on the midline of the brachials, and by the more tapering stem with shorter columnals. *Codiacrinus rarus* Jell in Jell & Holloway 1983 from the ?Early Devonian Humevale Formation at Winneke Reservoir may be distinguished by its narrower radials and consequently more conical cup, by its relatively higher infrabasals, and by its 1st brachials above arm forks not being sutured to each other. Czechoslovakian species *C. procerus* (Prokop,1973) and *C. ornatus* (Prokop, 1973) and the type species are all distinguished by their coarser granulose ornament among other features.

The variation in number of primibrachs in different rays of the same individual is unusual (Fig. 56F) and the ray with 2 primibrachs having 7 secundibrachs so that the 2nd forking takes place at the same level as in the adjacent ray with 4 primibrachs and 5-6 secundibrachs suggests some compensatory adjustment to arm growth.

This species is relatively common at NMVPL-252 but virtually every specimen is disrupted by plate dislocations making its shape difficult to establish and preventing any useful biometrics.

FIG. 56. *Codiacrinus secundus* sp. nov., all crowns in lateral view from NMVPL252. A, NMVP108660, ×1.9. B, NMVP108576, ×2.8. C, juvenile NMVP149364, ×4. D, NMVP108578, ×3.3. E, holotype NMVP108570, ×2.8. F, enlargement of distal articulating face of brachial NMVP108570, ×4.7.


A
B
C
D
E
F

Family CUPULOCRINIDAE
Moore & Laudon, 1943

Cupulocrinus d'Orbigny, 1850

TYPE SPECIES. *Scyphocrinus heterocostalis* Hall, 1847 from the Upper Ordovician of Canada; by monotypy.

REMARKS. Springer (1911) clarified the distinction between *Dendrocrinus* and *Cupulocrinus* based principally on the radial facet occupying all of the width of the radial in the latter but angustary in the former. Ramsbottom (1961) indicated a division within *Cupulocrinus* by noting that his Ashgillian species from Scotland are more similar to the type species than to North American species referred to the genus by Springer (1911). However, he did not indicate what features he used to make this division and no subsequent authors appear to have taken up this remark. Brower (1992) maintained the content of the genus with species as assigned except for *C. sepulchrum* Ramsbottom, 1961 (moved to *Dendrocrinus*) and *C. conjugans* for which he erected *Praecupulocrinus*. Despite this well expressed generic concept the 2 new Australian species which comply with the generic diagnosis are so different, that assessment of Ramsbottom's (1961) inference for further subdivision is necessary. The other problem with the Australian species is their geographic and stratigraphic separation. In the absence of any Silurian forms I am very dubious about assignment to this previously Ordovician genus. However, *C. austrogracilis* is so similar to *C. drummuckensis* Kolata, 1975 (=*C. gracilis* of Ramsbottom, 1961) that it is difficult to diagnose them effectively. Given the isolation of this Australian species I am very loathe to credit a genus with such an unusual range and distribution, but there is no morphological basis for excluding it from *Cupulocrinus*. The second Australian cupulocrinid is separated as *Stewbrecrinus* gen. nov. below.

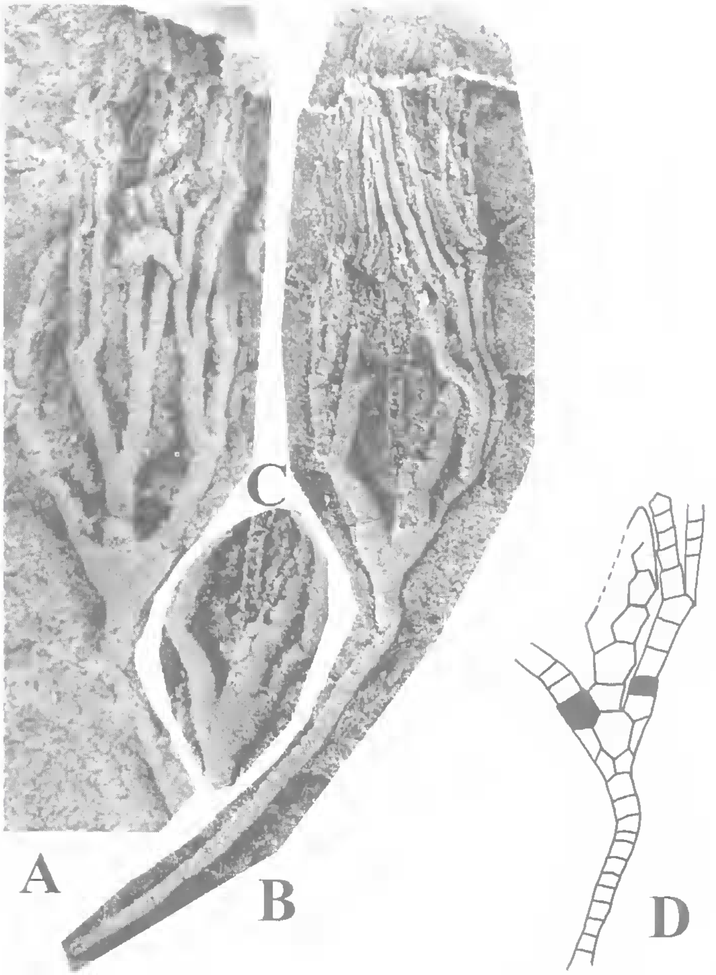


FIG. 57. *Cupulocrinus austrogracilis* sp. nov., holotype crown NMVP109194 from NMVPL1841, ×6. A, A ray view. B,C, posterior views. D, sketch of plate arrangement in posterior view.

Cupulocrinus austrogracilis sp. nov.
(Fig. 57)

ETYMOLOGY. Latin *australis*, southern and *gracilis* slender, also referring to it being southern version of *C. gracilis*.

MATERIAL. HOLOTYPE: NMVP109194 from NMVPL1841.

DIAGNOSIS. Crown 15mm long, subcylindrical. Cup low conical, moderately flared distally, with straight to slightly concave sides. Infrabasals short (1/4 or less of cup length), tapering proximally. Arms long and slender. Stem very slender, of uniform, relatively long, barrel-shaped columnals.

DESCRIPTION. Crown small, 14mm long. Cup 1.4mm long, conical, maximum width distally on radials 2mm. Thecal plates smooth. Infrabasals pentagonal, very short, upflared (not well defined on the specimen). Basals 5, hexagonal except for heptagonal CD basal, about as long as wide. Radials 5, pentagonal, as long as wide, largest plates in cup; radial facet plenary. Radianal pentagonal, in inferradial position proximal to C radial; anal X resting directly on CD basal, reaching almost to top of D radial and about halfway up C radial, supporting single large hexagonal anal leading into vertical column of similarly shaped plates decreasing in size distally. Arms isotomous, narrow, dividing 3 times on 4th primibrach, 3rd to 5th secundibrach and on various tertibrachs, 3rd divisions in same arm at same height, uniserial, nonpinnulate, with rectangular brachials throughout. Stem circular in section, of uniform barrel-shaped columnals.

REMARKS. This species is very similar to *C. gracilis* from the Middle Ordovician of North America (Kolata, 1975) particularly in structure of the posterior interray and even to relative size shape and plating of the anal tube, but differing only in the stem, height to width ratio of brachials and ratio of stem diameter to maximum cup diameter.

Stewbrecrinus gen. nov.

TYPE SPECIES. *Stewbrecrinus terryi* sp. nov.

ETYMOLOGY. An anagram from Webster plus the usual suffix for crinoids; for Gary Webster who has contributed greatly to Australian crinoid studies.

DIAGNOSIS. Cup dicyclic, usually expanding distally, with base of small to medium diameter. Radials usually wider than long, with radial facet plenary. Radianal in inferradial position proximal to C radial. Anal X very large, supporting a single large anal plate. Interprimibrachs small, irregular, numerous. Arms 5, uniserial, nonpinnulate, dividing isotomously at least 3 times, with primibrachs of more or less uniform width, with distinct patelloid processes at least in primibrachs. Stem heteromorphic, with nodals circular in section, with internodals decagonal.

REMARKS. Although this species satisfies the criteria for *Cupulocrinus* and is very closely

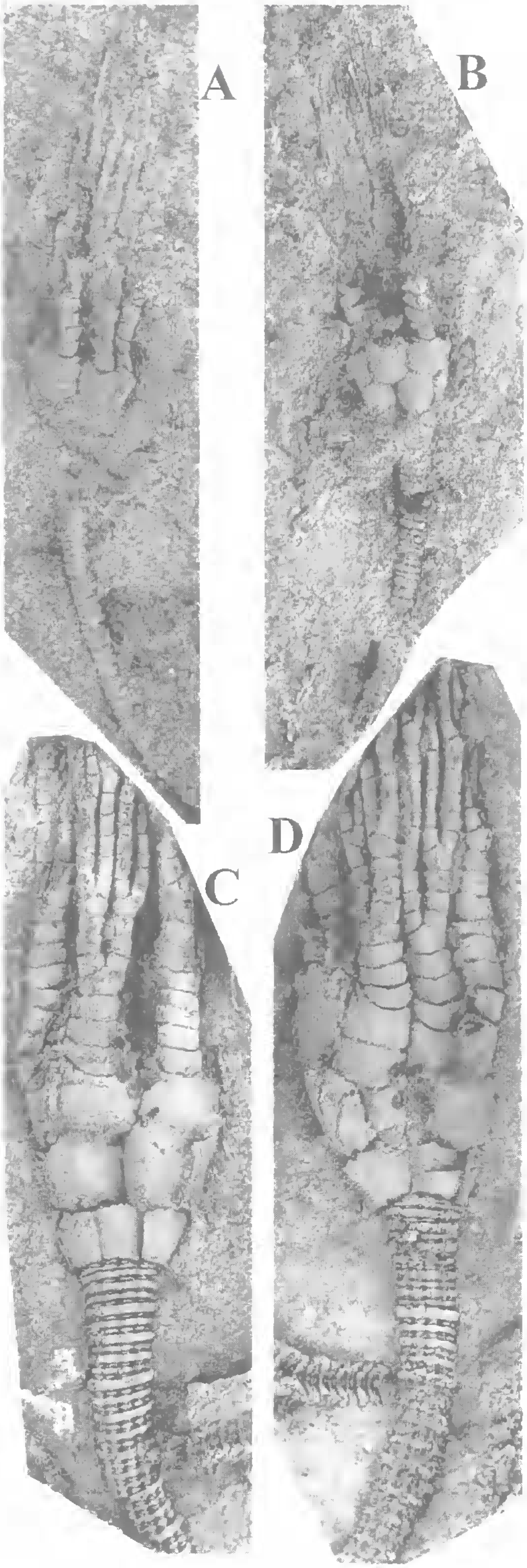


FIG. 58. *Stewbrecrinus terryi* gen. et sp. nov., crowns from NMVPL1924. A,B, part and counterpart of juvenile NMVP109766, ×1. C,D, part and counterpart of holotype NMVP109215, ×2.2.

allied to a few species of that genus its geographic and stratigraphic separation prompts me to allocate generic status. If in the future a lineage is found to link these species at least 2 species now assigned to *Cupulocrinus* could move to *Stewbrecrinus*. The new Australian Devonian genus may be distinguished from *Cupulocrinus* and *Praecupulocrinus* by its stem structure, by its curved rather than straight horizontal suture between radial and 1st primibrach and by the juvenile radial facet being much narrower than the radial plate. Brower (1992) showed in the species he erected that the radial facet occupies the full width of the radial even in the juvenile stage. However, growth series are not available for most species. The small interbrachial plates in the holotype of *S. terryi* may be a feature that indicates a generic grouping and if species with interbrachials are found in the Silurian the content of *Stewbrecrinus* may include Ordovician *C. humilis*, and *C. jewetti* (Springer, 1911).

Stewbrecrinus terryi sp. nov.
(Fig. 58)

ETYMOLOGY. For Terry Brady who helped collect crinoids at Kinglake West.

MATERIAL. HOLOTYPE: NMVP109215. PARATYPE: NMVP109766 from NMVPL1924.

DIAGNOSIS. As for genus.

DESCRIPTION. Crown subcylindrical, 30mm long, with arms more than twice as long as cup. Cup high conical, with basal diameter more than half summit diameter, dicyclic; plates smooth. Infrabasals 5, pentagonal, slightly longer than wide, with very high obtuse angle between 2 upper sides. Basals 5, hexagonal, as wide as long; CD basal larger than others, with 7 sides, supporting anal X symmetrically distal to it; anal X large, extending above radials, supporting one large anal plate medially over most of width of anal X and many tiny plates lateral to it. Radials 5, pentagonal except C radial subquadrate; radial facets angustary in small individual becoming plenary in large specimen, declivate, with evenly downcurved suture to 1st primibrach. Radianal pentagonal, in inferradial position proximal to C radial and separated from it by straight horizontal suture. Arms 5, branching isotomously at least 3 times, uniserial, nonpinnulate, with patelloid processes; primibrach 4 axillary except in D ray where 5th primibrach axillary; secundibrach 4 axillary; tertibrach 5 or 6 axillary. Stem heteromorphic, tapering slightly distally in most proximal part, circular in overall section, noditaxis N212, with internodals having serrated latus, tapering slightly over proximal 1cm.

REMARKS. This species is distinguished by its stem, its curved suture between radial and 1st primibrach and by its interbrachial plates.

The holotype is slightly crushed so that interradial areas between A, B and C rays are obliterated and anal X has ridden out over C radial. The interbrachial plates are only clear in the EA interradius; some are evident deep within the DE interradius. The edge of the anal X against the D radial is projected straight out of the surface of the latex just above the D radial and between it and the 1st primibrach of the D ray are a number of tiny plates suggesting strongly that a median column of large plates is laterally attended by fields of tiny plates; such plating of the anal interarea would align perfectly with that of *Cupulocrinus humilis* and *C. jewetti* as illustrated by Springer (1911). The numerous pits randomly distributed over the holotype cup and proximal primibrachs are interpreted as borings effected by another unknown organism.

Order DENDROCRINIDA Wachsmuth & Springer, 1886

Family DENDROCRINIDAE Wachsmuth & Springer, 1886

Dendrocrinus Hall, 1852

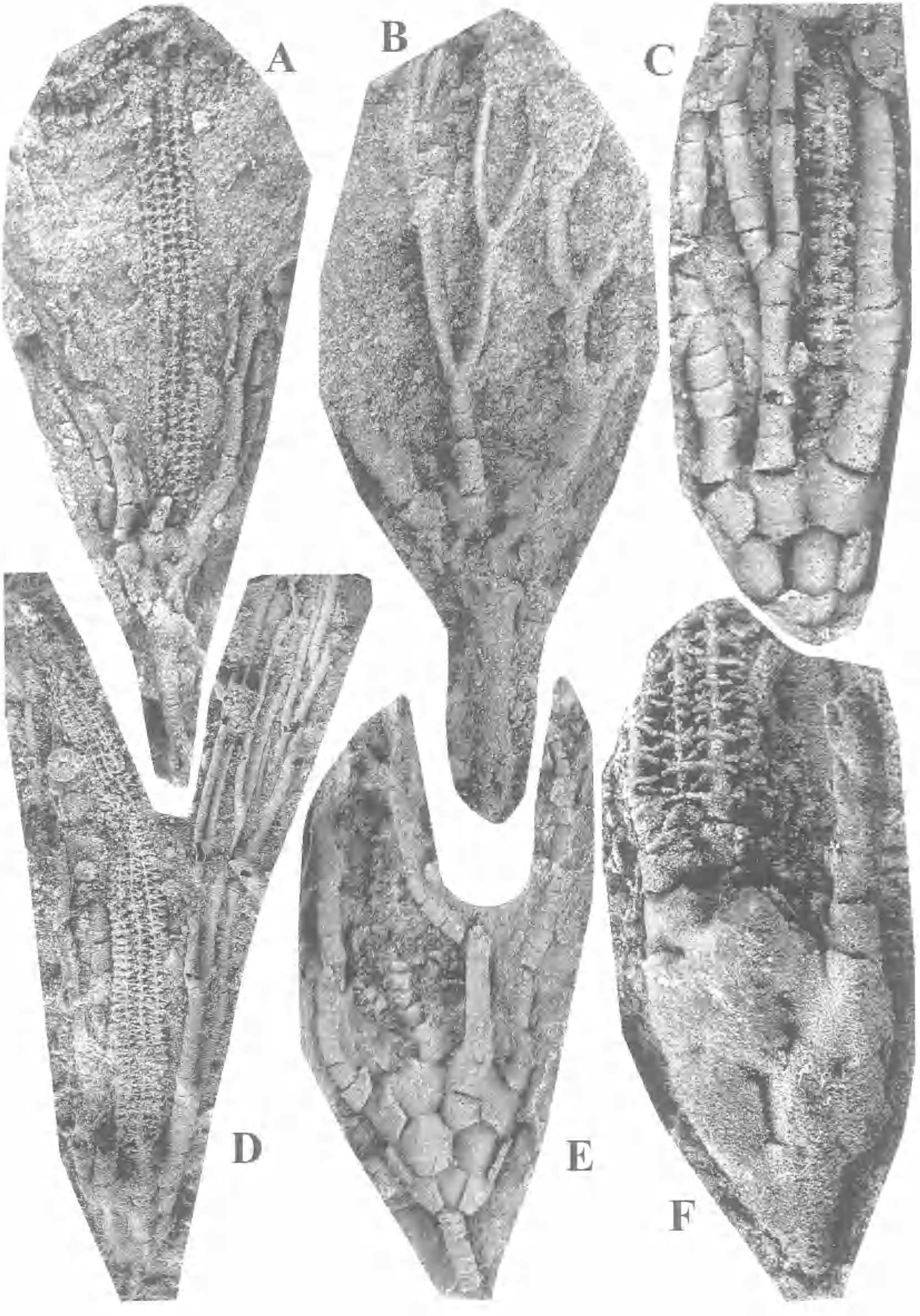
TYPE SPECIES. *D. longidactylus* Hall, 1852 from the Wenlock of New York; by original designation.

Dendrocrinus arrugius sp. nov.
(Figs 59-63)

ETYMOLOGY. Latin *arrugia*, a mine; from the vicinity of Comet Creek Mine.

MATERIAL. HOLOTYPE: NMVP109774. PARATYPES: NMVP109119, 109781, 109786, 109788-109790, 109802, 109813, 109823, 110630, 149365 all from NMVPL300 (Ludlow). OTHER MATERIAL: NMVP109187 from SW side of Bald Hills, NE of Kilmore; NMVP112133, 112137, 112138, 112140 and 112141 from NMVPL1925 (Ludlow). DOUBTFUL MATERIAL: NMVP108619, 149358 from NMVPL252 (Lochkovian).

FIG. 59. *Dendrocrinus arrugius* sp. nov., all crowns in lateral view from NMVPL300. A, anterior view of NMVP109813, ×3.5. B, NMVP109823, ×4. C, NMVP109790, ×4. D, posterior view of NMVP149365, ×1.5. E, posterior view of NMVP109781, ×3. F, C ray view of NMVP110630, ×3.


A
B
C
D
E
F

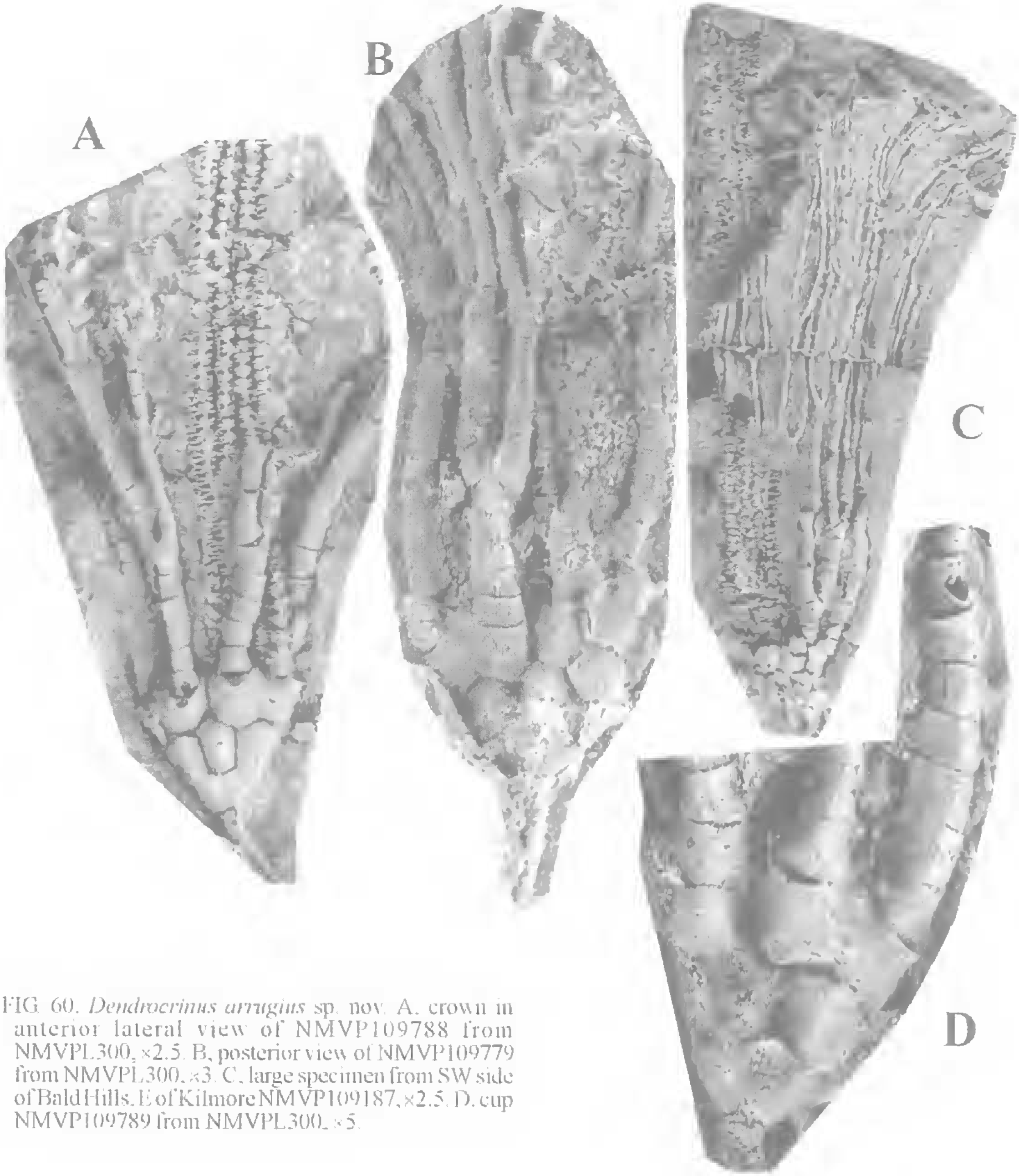
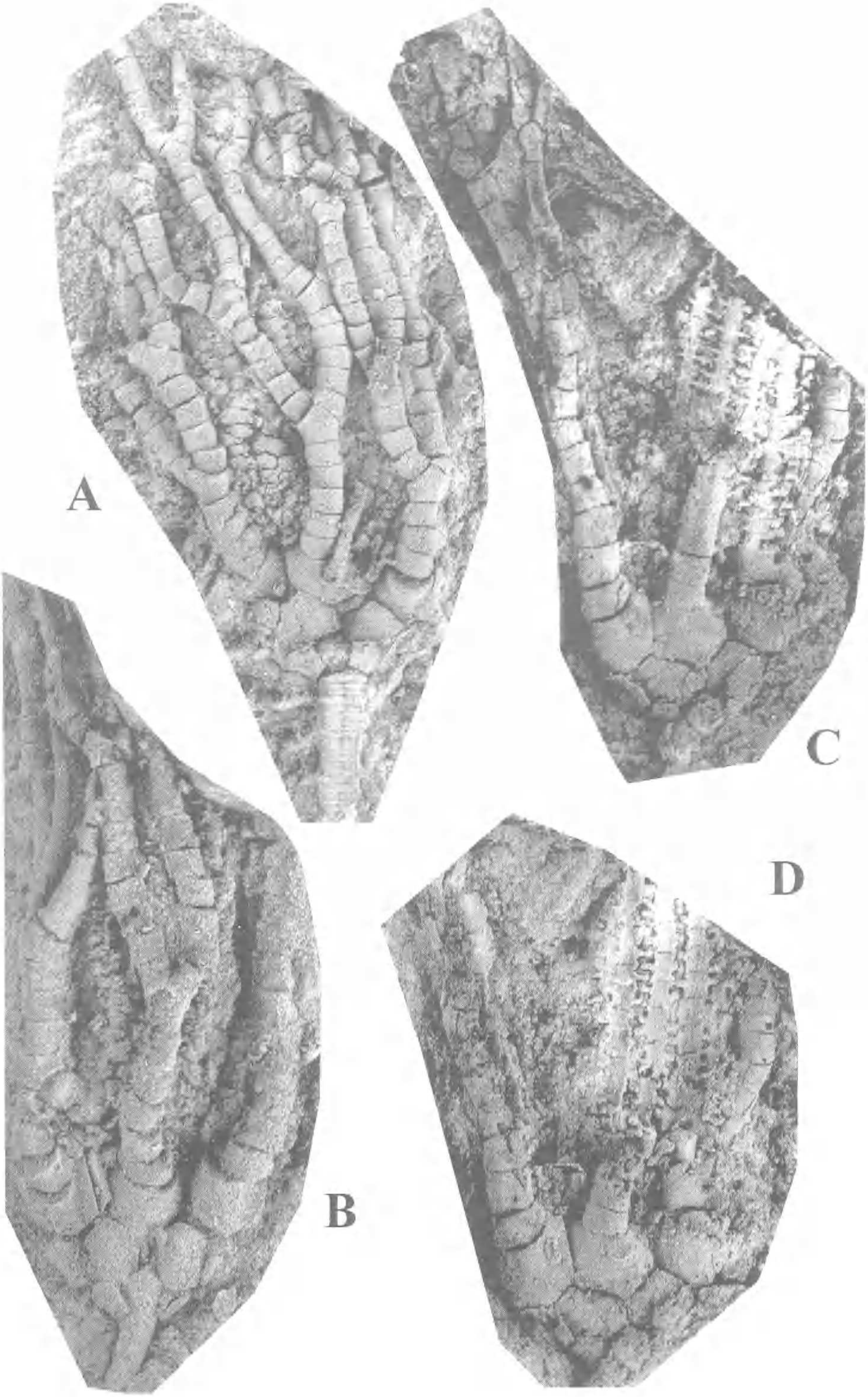


FIG. 60. *Dendrocrinus arrugius* sp. nov. A, crown in anterior lateral view of NMVP109788 from NMVPL300, ×2.5. B, posterior view of NMVP109779 from NMVPL300, ×3. C, large specimen from SW side of Bald Hills, E of Kilmore NMVP109187, ×2.5. D, cup NMVP109789 from NMVPL300, ×5.

FIG. 61. A, C, D, *?Dendrocrinus arrugius* sp. nov. A, crown in anterior view NMVP108619 from NMVPL252, ×3. C,D, D ray view of incomplete crown with successive latex pulls from same specimen showing exterior (C) and interior (D) of anal tube of NMVP149358 from NMVPL252, ×3. B, *Dendrocrinus arrugius* sp. nov. crown in anterior view NMVP109786 from NMVPL300, ×3.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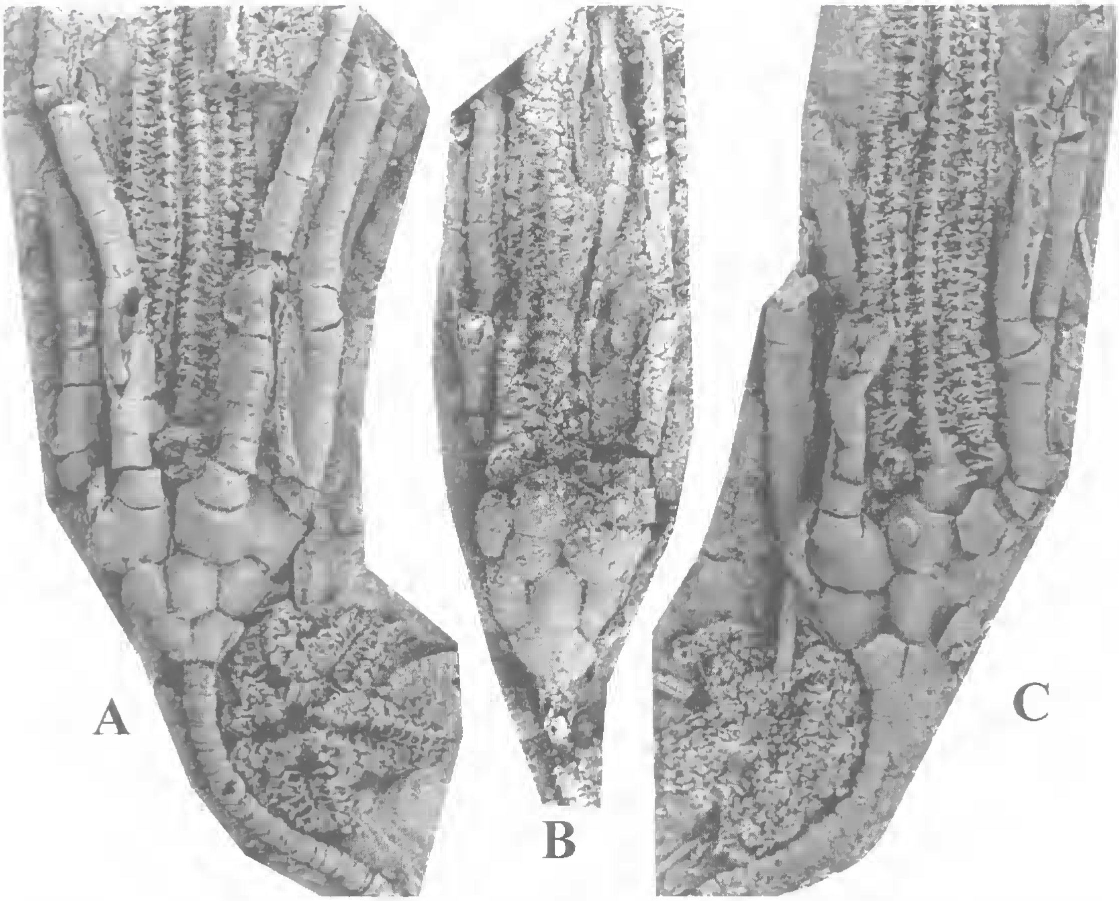
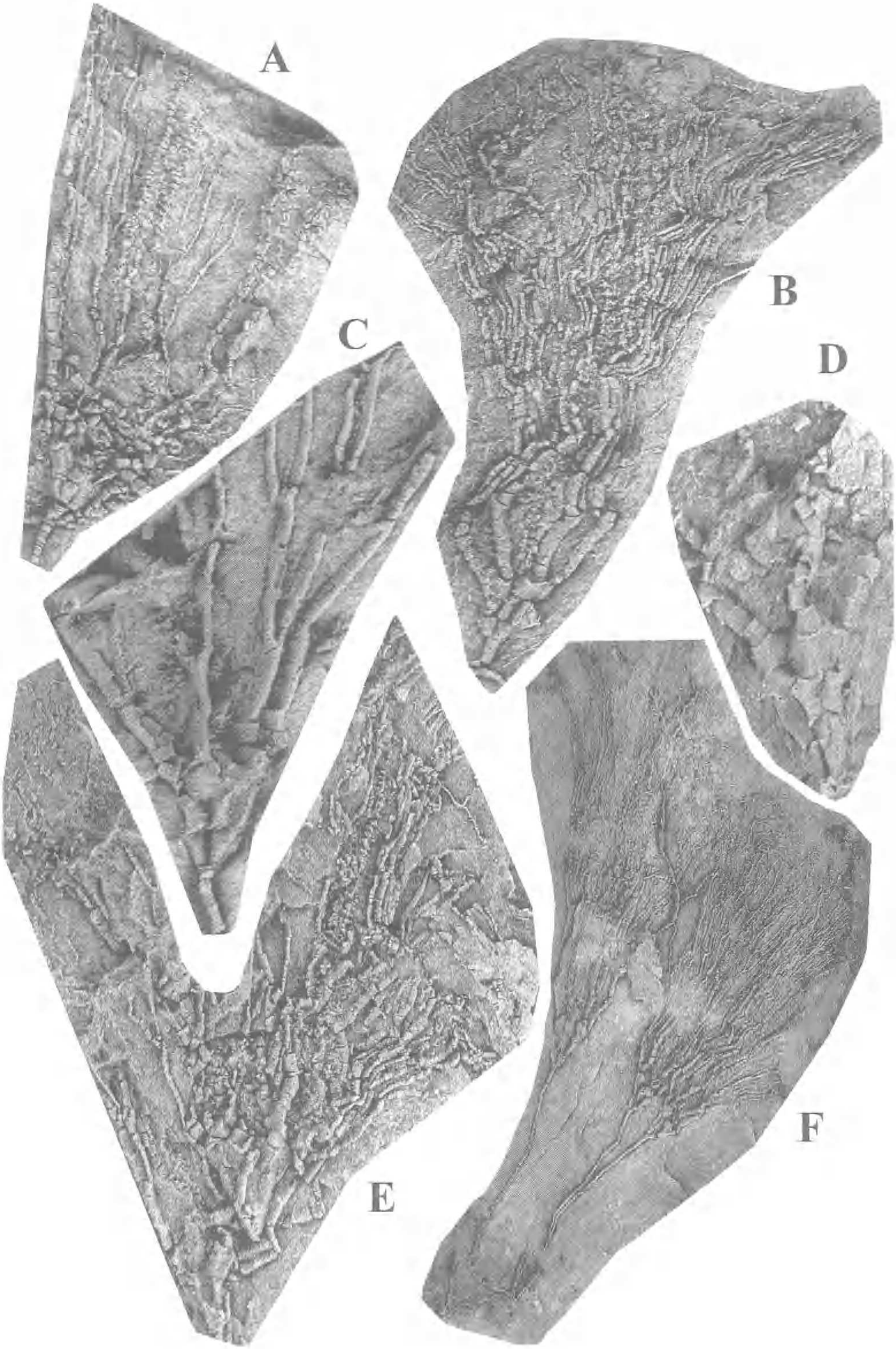


FIG. 62. *Dendrocrinus arrugius* sp. nov. A,C, part and counterpart of holotype crown with small asterozoan at base of NMVP109774 from NMVPL300, ×2.5. B, crown in C ray view of NMVP109790 from NMVPL300, ×3.

DIAGNOSIS. Crown subcylindrical to evenly subconical, 75mm long, with anal tube longer than arms. Cup plates thin, smooth except for ray ridges variably expressed from specimen to specimen. Radianal pentagonal, in inferoradial position beneath C radial. Radial facet occupying 3/4 or more of radial width, circular, gently declined. Anal X supporting 3 anals becoming plicate and succeeded by very tall plicate anal tube. Arms uniserial, isotomous, branching 5 or more times, nonpinnulate. Stem very narrow, circular in section, noditaxis N1, with longer nodals projecting slightly laterally.

DESCRIPTION. Crown very long, almost 10 times as long as maximum cup width, with anal tube extending well beyond arms. Cup conical, moderately long and flared, length about equal to maximum width. Thecal plates thin, smooth, with depressed corners in some specimens, with ray ridges well-developed on some specimens (particularly on radials). Infrabasals 5, pentagonal, longer than wide, tapering strongly proximally, with high obtuse angle between upper 2 sides, fully visible laterally except for basal flange against top of stem. Basals 5, hexagonal, longer than wide; posterior basal 7-sided, supporting anal X distally. Radials 5, hexagonal, with distal 2 sides angling up inside the radial facet; radial facet occupying 3/4 or more of radial width, circular, gently declined outwards, with

FIG. 63. *Dendrocrinus arrugius* sp. nov. all crowns from NMVPL1925. A, NMVP112140, ×1.8. B, NMVP112137, ×1.8. C, NMVP112133, ×1.8. D, NMVP149359, ×1.8. E, NMVP112138, ×1.8. F, NMVP112141, ×0.9.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weak transverse ridge. Anal plates in cup 2: anal X large, 6-sided, as long as wide, in radial circlet, on same level as C radial but slightly longer than D radial; radianal, pentagonal, in inferradial position proximal to C radial from which it is separated by a horizontal suture. Anal sac longer than arms, straight, of 10 vertical columns of plicate plates. Arms narrow, circular to deep U-shaped in section, with deep V-sectioned furrow on inside covered by small cuneate coverplates, isotomous, dividing 5 or more times, with primibrach 5 axillary (6 in A ray), secundibrach 8 axillary. Stem circular in section, heteromorphic, with nodals longer and of slightly greater diameter than internodals.

REMARKS. The only record of *Dendrocrinus* from Australia (*D. saundersi* Jell in Jell & Holloway, 1983) is possibly the youngest record of this essentially Ordovician genus globally, coming from near the Silurian/Devonian boundary. Ludlow species are apparently unknown but the type species is from the Wenlock of New York. This new species from the Ludlow helps to link *saundersi* back to the bulk of the genus. As with my discussion of *D. saundersi* many of the Northern Hemisphere species remain difficult to compare because they have not been revised this century. Nevertheless, it appears the plicate ornament on the very long anal tube beginning on the 1st anal distal to anal X, broader radial facets, radianal in inferradial position and low ray ridge ornament separate this from known species of the genus including the type which also has quite large lower anal plates filling the entire interray. *D. saundersi* has a smooth slender anal tube, fewer branches in the arms and more obviously beaded stem.

Material assigned to this species from NMVPL1925, in Dry Creek adjacent to the railway line under the bridge on Saunders Road, E of Kilmore, has a markedly different appearance to that from NMVPL300 to the SE. The NMVPL-1925 matrix has a fine crinkly cleavage and as the locality is close to a fold axis (Vandenberg, 1992) within the Kilmore East Synclinorium I suggest that a lot of the sharp angle bends in some cup plates are due to this cleavage. Depending on their orientation to the tectonic forces some specimens have been shortened others have been elongated and narrowed. However, the very long plicate anal tube (Fig. 63A,E) and the radianal symmetrically below C radial (Fig. 63D) along with the nature of the stem and numerous arm branchings are sufficient to be confident of the identification.

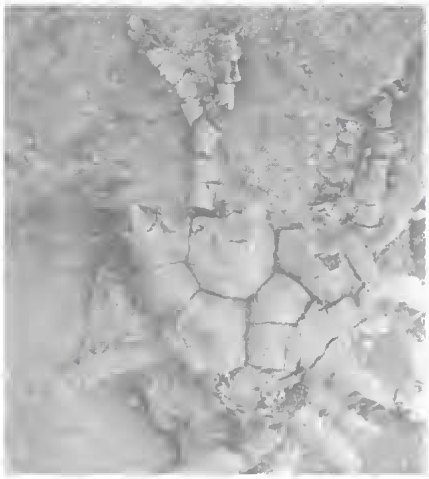


FIG. 64. *Dendrocrinus* sp. B ray view of cup NMVP100491 from NMVPL1927, ×3.

Two specimens from NMVPL252 in the Lochkovian are very tentatively referred to this species even though only the anterior is available. The more complete specimen (Fig. 62A) matches extremely closely, typical specimens from NMVPL300 (Fig. 62B). In the Devonian specimen the stem appears wider relative to the cup and what appears to be the anterior of the anal tube running from between the A and B radials to about 11 o'clock beneath the arms lacks the plicate ornament. However, the second specimen from the same locality clearly shows the plicate ornament. There are no other known species from NMVPL252 to which these specimens could be assigned unless they represents a new taxon. Therefore we make very doubtful assignment to *D. arrugius* fully aware that this would infer an extremly longranging species, Ludlow to Lochkovian. A number of other species do have this range in the Melbourne Trough sedimentary structure.

Dendrocrinus sp.
(Fig. 64)

MATERIAL. NMVP100491 from NMVPL1927 at the crossing of Broadhurst Creek by the Kilmore to Wandong Road.

DESCRIPTION. One side of cup (A-C rays only) preserved; cup low, conical, of smooth thin plates with broad low median ray ridges. Infrabasals 5, pentagonal, more or less equidimensional, with proximal margin projecting out medially. Basals

5, hexagonal, longer than wide; A-B basal with straight horizontal suture dividing it into 2 pentagonal plates. Radials 5, pentagonal except B radial with an extra side against radianal and C radial with one less side because of horizontal base against radianal, with low indistinct radial ridges emanating from centre just below radial facet angustary, only gently declivate. Radianal only anal plate available, pentagonal, in inferradial position proximal to C radial, separated by horizontal suture, with low ridge running proximally from C radial and dividing near midlength and continuing onto basals. Arms 5, deep U-shaped in section, with deep V-shaped groove on inner side, apparently isotomous, with 3rd primibrach axillary. Stem unknown.

REMARKS. This specimen is too incomplete to provide a full species concept but it has some features that make it unique. It is the only crinoid from this horizon. The radianal in inferradial position proximal to the C radial identifies it as *Dendrocrinus*. The divided AB basal is unknown in any other cladid; it could be an aberrant specimen, which I consider most likely or it could be the last remnant of a 4th circlet of cup plates that may have been in its ancestry. The latter possibility suggests derivation from *Aethocrinus* as suggested by McIntosh (1983).

Family PLICODENDROCRINIDAE nov.

DIAGNOSIS. Cup low to high conical; thecal plates with narrow, radial ridges; infrabasals 5; radial facets poorly developed, transverse ridge usually absent but when present bisected by prominent V-shaped ambulacral groove; 2 or 3 anal plates in cup; rarely with inferradianal; radianal either pentagonal and in inferradial position or quadrangular; arms usually isotomous, rarely heterotomous; outer faces of proximal brachials mostly angular; anal sac straight, inflated, of thin plicate plates.

GENERA ASSIGNED. *Plicodendrocrinus* Brower, 1995 (Upper Ordovician (Ashgill); central USA). *Compagicrinus* Jobson & Paul, 1979 (Lower Ordovician (Arenig); northern Greenland). *Holmesocrinus* gen. nov. (Silurian (Ludlow); central Victoria).

REMARKS. The concept of this family was first documented in an unpublished thesis by George McIntosh (1983) and when he refereed this paper he insisted that I name the family from this date upon which I insisted that I acknowledge the origin of the concept. McIntosh (1983) separated *D. casei* from *Dendrocrinus* as type of a new genus and used that genus as the type of a subfamily of the Dendrocrinidae including *Compagicrinus* and a new genus based on *Botryocrinus reimanni* Goldring, 1934 from the Middle Devonian of New York.. Thus when Brower (1995) established *Plicodendrocrinus* with *D. casei* as type species he endorsed McIntosh's generic concept but with a different name. It was the group of species now asigned to *Plicodendrocrinus* that Jobson & Paul (1979) had in mind when they showed *Compagicrinus* giving rise to *Dendrocrinus*. Their figure would now be modified to show the Plicodendrocrinidae continuing on beyond the Middle Silurian and a parallel arrow for the Dendrocrinidae which has very similar stratigraphic range. McIntosh's subfamily concept remains in tact and now takes its name from Brower's genus. In this paper I employ McIntosh's subfamily concept at family level because with the description below of Ludlow and Lochkov members it is clear that the lineage continued from the Lower Ordovician through the middle Palaeozoic independent of *Dendrocrinus* and although it may contain the ancestor of the Dendrocrinidae that is a recognisably distinct lineage that should be treated as such. The diagnosis used here is McIntosh's with minor modification to accept the Australian genus.

Plicodendrocrinus Brower, 1995

TYPE SPECIES. *Poteriocrinites (Dendrocrinus) casei* Meek, 1871 from the Upper Ordovician of USA; by original designation.

DIAGNOSIS. Two anal plates in cup; inferradianal absent; superradianal pentagonal, in inferradial position proximal to C radial. Anal sac inflated, elongate, of staggered columns of strongly plicate plates proximally, with numerous (20-30) randomly arranged sets of sac plates distally. Arms isotomous, non-pinnulate; proximal brachials angular or cuneiform, with distinct cornice-like flaring in distal direction. Stem pentastellate or decagonal to round, lacking pentameres.

INCLUDED SPECIES. The type, *Dendrocrinus granditubus* Ramsbottom, 1961, *D. rugocyathus* Ramsbottom, 1961, *Dendrocrinus proboscidiatus* Billings, 1857 and *P. australis* sp. nov.

Plicodendrocrinus australis sp. nov.
(Figs 65B-E, 66B)

ETYMOLOGY. Latin *australis*, southern.

MATERIAL. HOLOTYPE: NMVP100191. PARATYPE: NMVP112129 from NMVPL252.

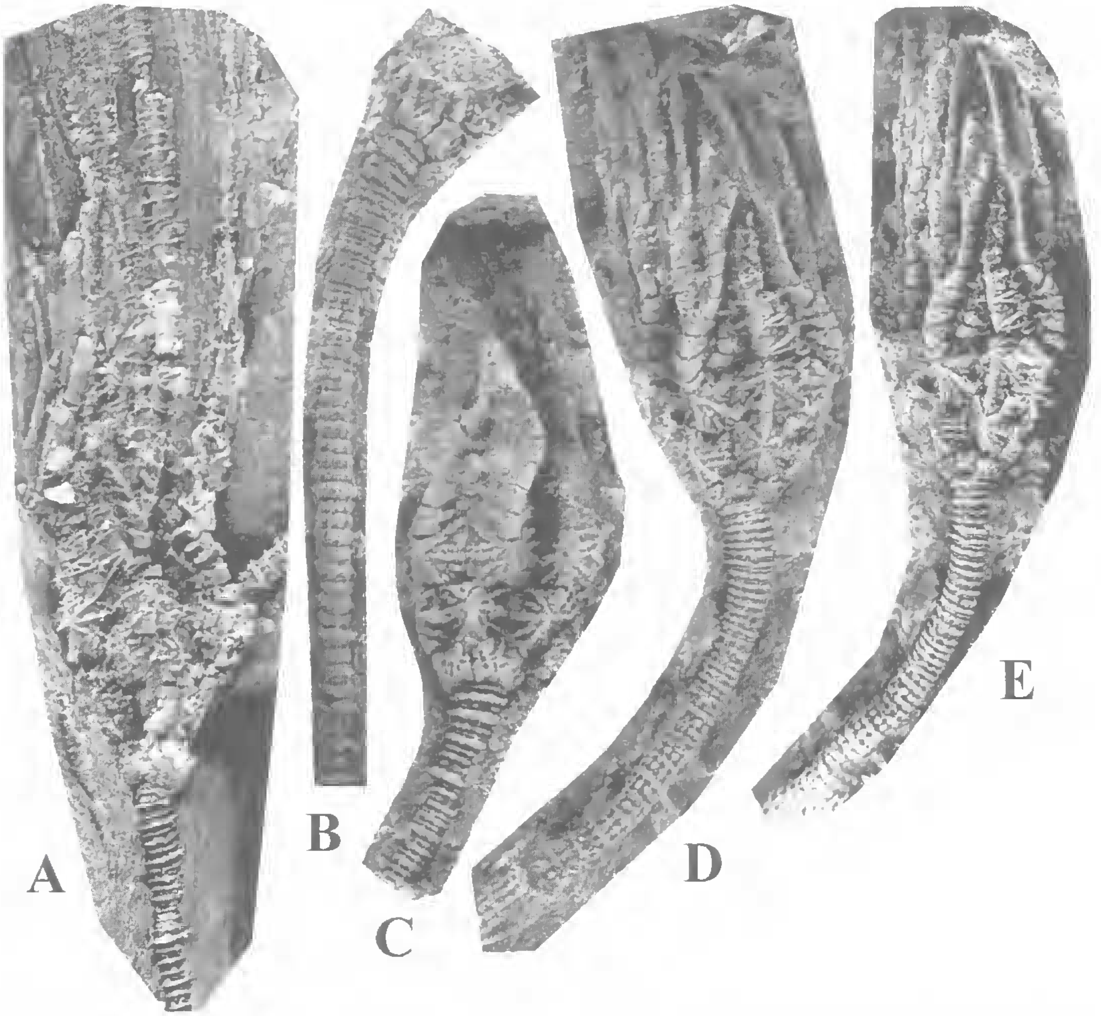


FIG. 65. A, *Shimtocrinus richi* sp. nov., posterior view of crushed crown of holotype NMVP149390 from NMVPL1990, ×2.5. B-E, *Plicodendrocrinus australis* sp. nov. B,C, part and counterpart of crown (B stem and infrabasal circlet only) NMVP112129, ×2. D,E, D ray and posterior views of holotype crown NMVP100191, ×3.

DIAGNOSIS. Thecal plates with low, narrow radial ornament and fine subsidiary interradial ridges parallel to the radial ridges; radial facet narrow relative to radial width; 4th primibrach axillary; arms isotomous, dividing at least 3 times. Stem decagonal, round proximally, with distinct nodals and internodals becoming less differentiated distally.

DESCRIPTION. Crown subcylindrical, 15mm long. Cup low, conical, wider than long. Thecal plates, thin, prominently ornamented with vertical (on radials and posterior interray), horizontal (on radials and basals) and diagonal (on all plates) ridges continuous from plate to plate; major ridges at right angles to interplate sutures, radiating from just below facet on radials, from middle of basals, radianal and anal X and from midpoint of proximal margin against stem on infrabasals; secondary ridges between main ridges running to corners of plates. Infrabasals 5, pentagonal, as wide as long, smallest plates in cup, upflared, visible in lateral view except for bases resting on stem. Each infrabasal with 3 ridges originating from centre of base; 2 run diagonally onto adjacent basals, 3rd vertical to upper corner not extending further. Basals 5, hexagonal, largest plates in cup, longer than wide, with central elevated point as origin of 6 major ridges continuous onto contiguous plates

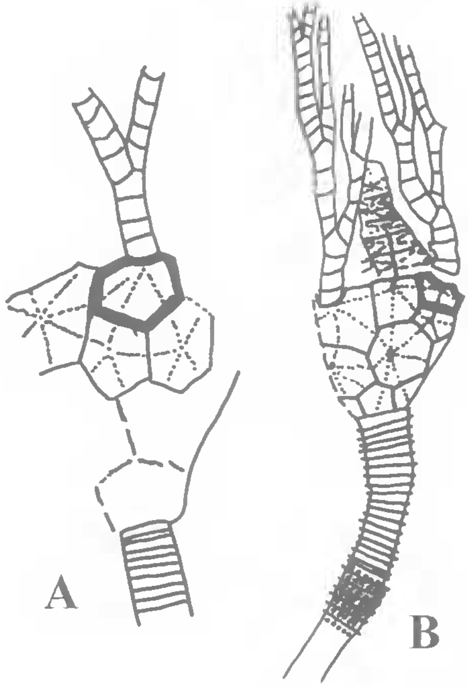


FIG. 66. Sketches of holotypes to show posterior plating (C radial heavily outlined). A, *Shintocrinus richi* sp. nov., B, *Plicodendrocrinus australis* sp. nov.

at right angles to interplate sutures, with secondary ridges running to plate corners not always originating at centre; posterior basal 7-sided and with 7 major ridges, with 3 distal riges running to D radial, anal X and radianal. Radials 5, pentagonal, width about equal to length, with 6 major ridges radiating from centre just proximal to facet, with 2 horizontally to adjacent radials, 2 diagonally to basals and 2 diagonally to distal corners of radial distal to facets. Radial facets angustary, U-shaped, just distal to midlength of radial. Two anal plates in cup; radianal pentagonal, in inferradial position proximal to C radial, with 5 main ridges radiating from centre to contiguous plates; anal X large, symmetrically distal to CD basal in radial circlet, with 7 main ridges radiating from the centre, with asymmetrical ridge diagonally to radianal. Anal sac long, composed of columns of plicate plates, with strong vertical ridge on posterior midline. Arms isotomous, non-pinnulate, narrow and deep giving high U-shaped section with angular outer margin, bifurcating on 4th primibrach, 4th secundibrach and 7th tertibrach. Stem decagonal (most noticeable in internodals) in section, consisting of alternating nodals and internodals, markedly heteromorphic in proximal part of stem but almost uniform distally.

REMARKS. This species is most simply distinguished from the other 5 species, all from the Ordovician of the Northern Hemisphere, by its decagonal to rounded stem but also by its finer, more elaborate thecal plate ornament. Although the holotype cup is crushed the central peak of the radianal and the C radial are in a vertical line to confirm this dendrocinid feature. Although the upper extension of the anal sac is not available it does not seem likely, from the arms closing around the sac in the holotype, that it is so prominently expanded as it is in *P. grandituhus*. *P. rugocyathus* is distinguished by the coarse radial ornament on thecal plates.

Shintocrinus gen. nov.

TYPE SPECIES. *Shintocrinus cometensis* sp. nov.

ETYMOLOGY. An anagram from Intosh, for George McIntosh of the Rochester Museum.

DIAGNOSIS. Two anal plates in cup; radianal subquadrate to pentagonal; anal sac inflated, of 8 staggered rows of plicate sac plates; arms isotomous; proximal brachials angular, with distinct cornice-like flaring; stem round.

INCLUDED SPECIES. The type, *S. richi* sp. nov. and possibly *S. costatus* (Angelin, 1878) (i.e. *Pycnosaccus scrobiculatus* in part of Springer, 1926, pl. 11, fig. 10).

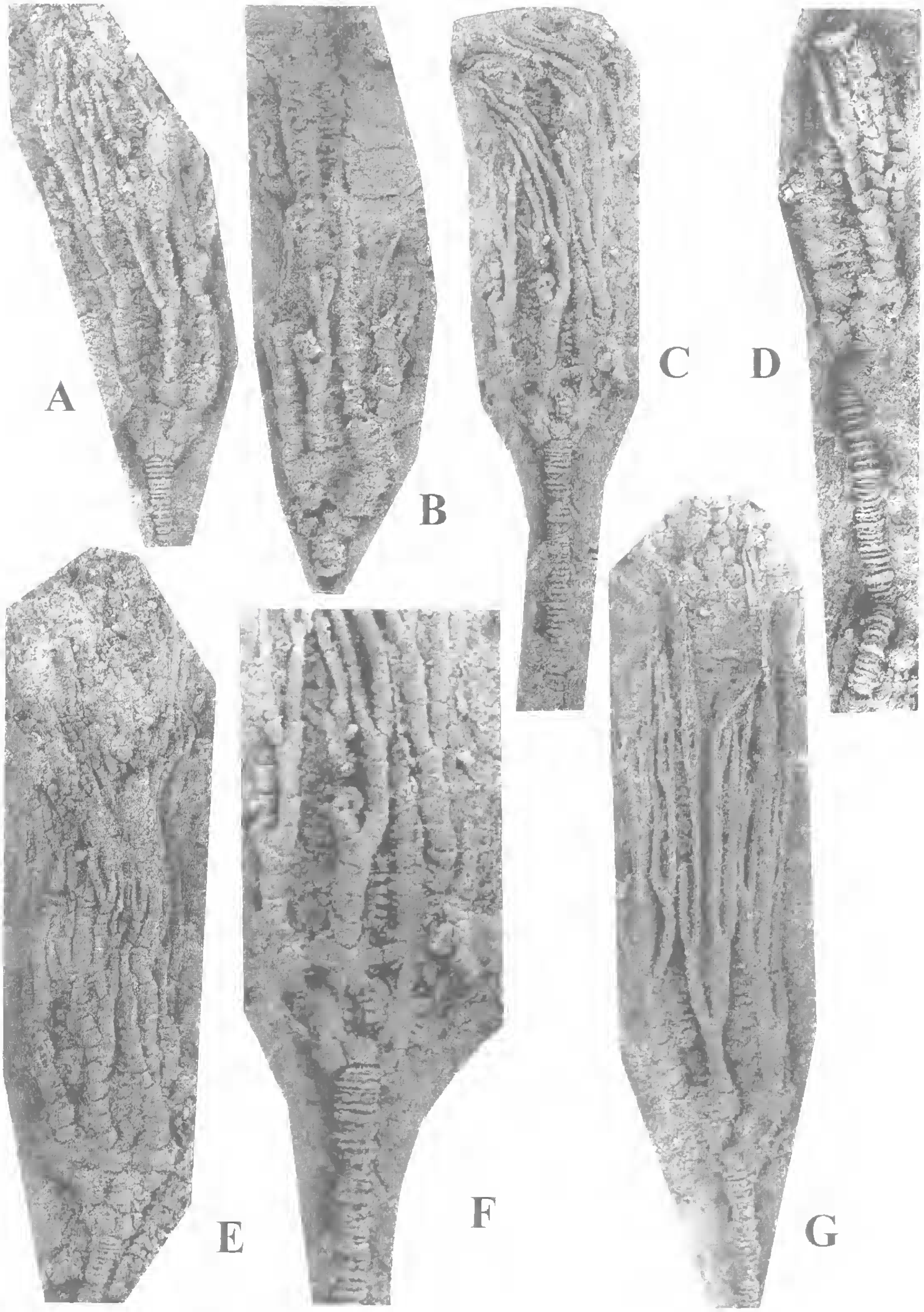
REMARKS. This genus shares with *Plicodendrocrinus* its isotomous arms, its conservative radial facets, thin cup plates and straight anal tube but differs from it principally by the position of its radianal, by its arms branching only 3 times and round stem. *Shintocrinus* differs from *Holmesocrinus* in the nature of the stem, slightly different position of the radianal (more to left of C radial than inferoradial) and in type of ornament although the latter is variable within *Holmesocrinus*.

Shintocrinus cometensis sp. nov.
(Figs 67, 68)

ETYMOLOGY. From the vicinity of Comet Creek Mine.

MATERIAL. HOLOTYPE: NMVP109778. PARATYPES: NMVP109771, 109801, 109803, 109808, 109812, 109818, 149366-149368 all from NMVPL300.

DIAGNOSIS. Cup low conical; thecal plates with many radiating rays (i.e. more than 1 per side) particularly in basal circlet; radials about as long as wide; radial facet very narrow, circular;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two anal plates in cup; radianal subquadrate, below and just left of C radial; anal X large with dominant radial ornament; anal sac longer than arms, with 4 strong vertical ridges joined by finer diagonal ridges, with distal portion of irregular polygonal plates; stem circular.

DESCRIPTION. Crown conical, 35mm long, with arms 6 times as long as cup. Cup low conical, slightly wider than long. Thecal plates thin, ornamented with broad low radial ridges continuing across sutures between basal and radial circlets and anal plates.

Infrabasals 5, pentagonal, about as wide as long, smallest plates of cup, upflared, completely visible in lateral view except for proximal flange resting on stem, smooth except for broad low ridge on distal sutural margins connecting to similar ridges on adjacent basals. Basals 5, hexagonal, about as wide as long, about same size as radials, with low wide main ridges forming vertically elongate cross and continuing to radials and infrabasals, with horizontal secondary ridges (2 or 4) continuing horizontally onto adjacent basals; posterior basal heptagonal, supporting anal X distally, with strong ridge from centre continuing onto anal X and distally along anal sac, with strong upper ridge running onto radianal rather than C radial. Radials 5, pentagonal, as wide as long, with 4 prominent ridges radiating from centre just proximal to radial facet and continuous onto adjacent basals, radials, anal X or radianal; radial facet angustary, U-shaped, with distal 1/2 of radial extending distally around facet. Anal plates in cup 2: anal X pentagonal, in radial circlet, with 5 strong radial ridges to posterior basal, anal sac, adjacent radials and radianal; radianal subquadrate, proximal and left of C radial, with broad low crossed ridges continuing to contiguous plates. Anal sac longer than arms, consisting of columns of plicate anals proximally becoming less regular and polygonal distally, with strong low wide ridge along posterior side on proximal portion. Arms isotomous, narrow, deep U-shaped sectional shape, with angular outer edge, dividing 4 times at 4th primibrach, 4th secundibrach, 7th tertibrach and at a similar distance again (no specimen well enough preserved to be able to count distal brachials). Stem circular in section, of uniform diameter over available length, irregularly dimorphic with some sections of stem having 3 or 4 identical columnals adjacent to each other but most of stem with nodals of larger diameter alternating with smaller internodals in noditaxis pattern N212, with subtle expression of decagonal section in some internodals in some specimens.

REMARKS. This species is distinguished from *S. richi* by its cup plate ornament with secondary ridges, probably by the shape of the radianal and by the slightly different stem structure. The Swedish *S. costatus* has some secondary ridges on the thecal plates but the major ridges are still narrow and discrete by comparison with the Australian species.

Shintocrinus richi sp. nov.

(Figs 65A, 66A)

ETYMOLOGY. For Tom Rich, my former colleague at the Museum of Victoria.

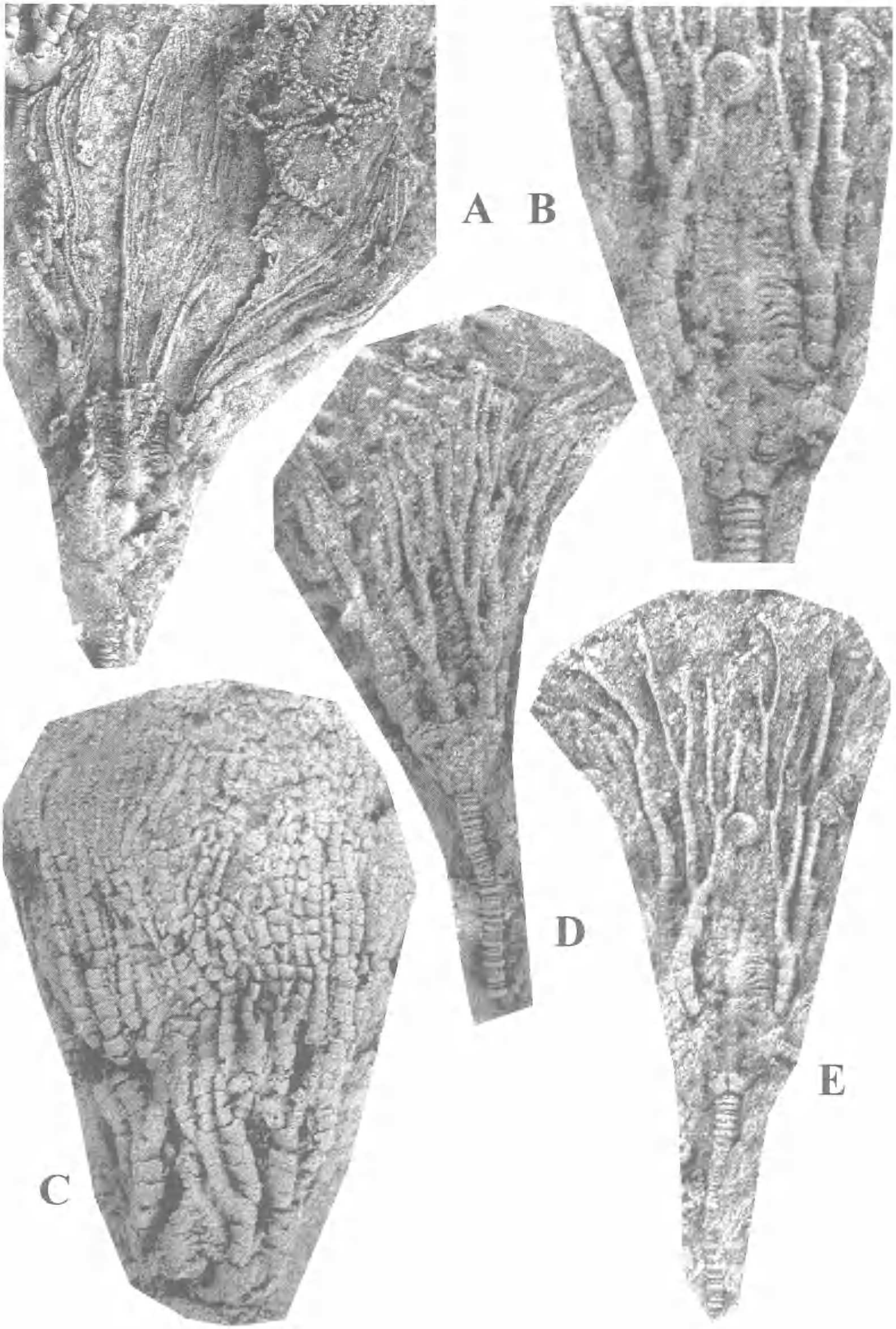
MATERIAL. HOLOTYPE: NMVP149390 from NMVPL1990.

DIAGNOSIS. Radianal large, pentagonal, proximal and left of C radial. Thecal plate ornament of fine radial ridges continuing distally on anal tube.

DESCRIPTION. Crown conical, estimated 50mm long. Cup low conical. Thecal plates thin, ornamented with narrow wire-like radial ridges continuing across sutures between all cup and anal tube plates.

Infrabasals and basals collapsed, indistinct except for part of BC basal showing ornament. Radials 5, pentagonal, as wide as long, with 4 prominent ridges radiating from centre just proximal to radial facet and continuous onto adjacent basals, radials, anal X or radianal; radial facet angustary, U-shaped, with distal 1/2 of radial extending distally around facet. Anal plates in cup 2: anal X 7-sided, in radial circlet, large with 7 radial ridges to posterior basal, anal sac, adjacent radials and radianal, with vertical ones stronger than others; radianal proximal and left of C radial, with 5 fine radial ridges suggesting pentagonal shape (outline not clear). Anal sac long, of columns of plicate anals, with strong ridge along posterior side proximally. Arms isotomous, narrow, deep U-shaped sectional shape, with angular outer edge, dividing at least 3

FIG. 67. *Shintocrinus cometensis* sp. nov., all crowns from NMVPL300. A, NMVP149366, ×3. B, NMVP109818, ×3. C,F, D ray view of NMVP109801, ×3 and ×6. D, C ray view of NMVP149367, ×3. E, NMVP109803, ×3. G, NMVP109812, ×2.75.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(and probably 4) times, first division at 4th primibrach. Stem circular in section, of uniform diameter over available length, heteromorphic, columnals long, of uniform diameter, with latus near midlength of differing widths.

REMARKS. This species is based on a single crushed and poorly preserved specimen preserved in friable siltstone so its assignment could be considered tentative. It is distinguished from other species of the genus by its sharp fine radial ridge ornament and probably pentagonal radianal. Its crown resembles that of *Plicodendrocrinus australis* sp. nov. but that species has its radianal directly beneath the C radial and a distinctive stem although the proximal part of its stem resembles that of *S. richi*. Doubtless these species of *Plicodendrocrinus* and *Shintocrinus* are closely related but knowledge of the Australian species is poor so I refrain from any speculation on relationships.

Holmesocrinus gen. nov.

TYPE SPECIES. *Holmesocrinus enidae* sp. nov.

ETYMOLOGY. For Frank and Enid Holmes of Melbourne for their unstinting assistance in the field and donation of specimens. The specific epithet is for Enid who collected the holotype.

DIAGNOSIS. Cup long, slender, conical. Thecal plates with prominent radial ridge ornament or smooth. Infrabasals 5, pentagonal, with ridges crossing close to proximal margin and running into different lobes of stem. Basals 5, hexagonal except for heptagonal CD basal, with radial ridge ornament. Radials 5, with horseshoe-shaped facets more than 1/2 radial width; C radial with only 5 radiating ridges, smaller and further distally in cup than others. Arms uniserial, narrowly horseshoe-shaped in section, branching isotomously 4 times; primibrachs, secundibrachs and tertibrachs 4 or 5 axillary. Radianal pentagonal, proximal and slightly left of C radial; anal X heptagonal, in radial circlet, with 5 radiating ridges, supporting single anal plate above; anal tube as long as arms, of plicate plates. Stem pentalobate, heteromorphic, with large circular nodals separated by 3 pentagonal internodals the middle one being slightly wider than the other 2, noditaxis N212.

REMARKS. The prominent radial ridge ornament is distinctive of earliest cladids. *Aethocrinus* Ubaghs, 1969 (type species *A. moorei* Ubaghs,1969 from the Lower Ordovician of southern France) is distinguished by the extra circlet of plates in the cup, pentameric stem and wider radial facet. *Holmesocrinus* is assigned to the Plicodendrocrinidae because of the width and horseshoe-shape of radial facets, long anal tube of plicate plates, uniserial non-pinnulate arms, 2 circlets of plates proximal to the radials and radianal situated proximal and only slightly left of the C radial. It differs from other members of the family principally in its distinctive stem structure of pentagonal internodals between greatly expanded circular nodals. It is further separated from *Plicodendrocrinus* by its radianal being proximal and left of the C radial and from *Compagicrinus* by having 1 radianal. It most closely resembles *Shintocrinus* but that genus has anal X in the radial circlet with its distal margin at the same level as the distal margin of the radials and a more elaborately ornamented and longer anal tube. *Shintocrinus* and *Holmesocrinus* almost certainly evolved from a common ancestor among Ordovician or Llandovery plicodendrocrinids but represent separate lineages clearly defined by the different stem structures.

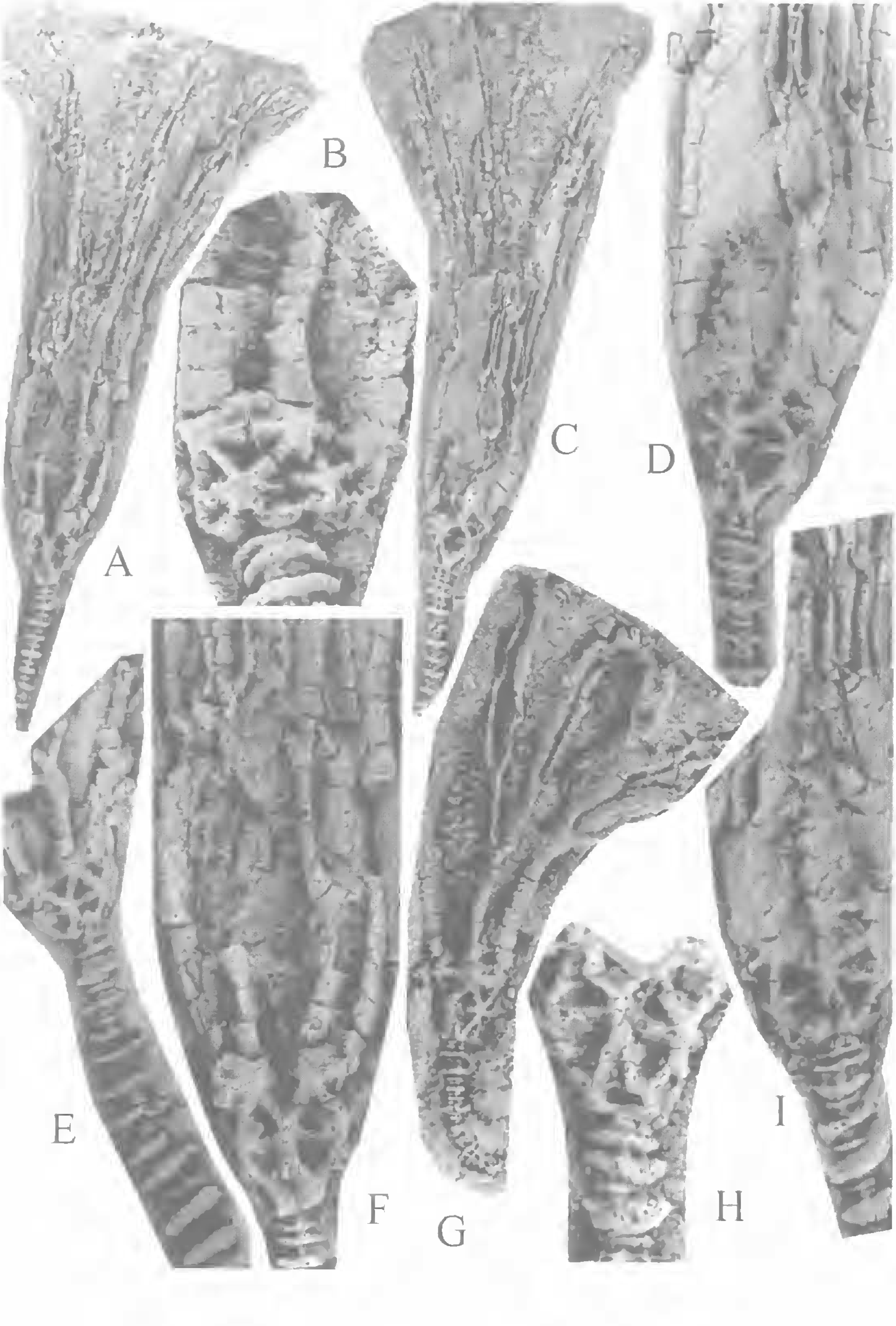
Holmesocrinus enidae sp. nov.
(Figs 69, 70)

MATERIAL. HOLOTYPE: NMVP100112. PARATYPES: NMVP100102, 100104, 100107, 100108, 107107 all from NMVPL1923.

DIAGNOSIS. Cup strongly ornamented with prominent narrow radial ridges on all plates. Radianal with 5 radiating ridges.

DESCRIPTION. Crown subcylindrical, 45mm long, with arms more than 8 times as long as cup. Cup low conical. Infrabasals 5, each with midline running into a longitudinal groove on stem, with rounded ridges emanating from near bottom corners then crossing near proximal edge and extending across distal sutures at right angles, without transverse circular ridge. Basals 5, hexagonal, each with 3 ridges normal to margins and crossing each other in middle of plate, with ridges continuous with others on adjacent circlets and third with annular ridge on other basals; CD basal heptagonal, with extra ridge beginning at

FIG. 68. *Shintocrinus cometensis* sp. nov., all crowns in lateral view from NMVPL300. A, posterior view of NMVP109771, ×2.75. B,E, posterior view of holotype NMVP109778, ×6 and ×3, respectively. C, posterior view of NMVP109808, ×4. D, NMVP149368, ×3.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midpoint and running distally across anal X onto anal tube, otherwise ridges same as on basals. Radials in contact except in posterior interray where anal X intervenes in circlet, hexagonal, with horseshoe-shaped radial facet almost horizontal to slightly downsloping and occupying approximately 1/2 width of plate, with same 3 ridges as on basals but crossing just proximal to radial facet, with separate ridge beginning at point of crossing of other 3 and running distally along arm, with 2 diagonal ridges finishing at distal margin of radial; C radial smaller than others, further distally in cup than others, with B radial proximal and right of it so that 1 ridge does not continue and only 5 plus the arm meet in the crossing of the ridges, in contact with radianal and anal X radianal pentagonal, with some variation in ridge pattern across it but with ridges crossing each suture at right angles to continue 2 diagonal ridges but introducing a section of transverse ridge that is between the basal and radial circular ridges; anal X 7-sided, supporting very long anal tube of strongly plicate plates. Arms narrowly horseshoe-shaped in section, with primibrach 4 or 5 axillary with apparent consistency in each individual, with brachials becoming shorter distally, with 1st secundibrachs and 1st tertibrachs in contact for a short distance (< height of the columnal) distal to the midline of the axillary. Stem pentagonal to pentalobate in section, becoming circular distally, heteromorphic; nodals large, circular, twice diameter of rest of stem, almost twice length of other columnals; noditaxis N212; full length of stem not known.

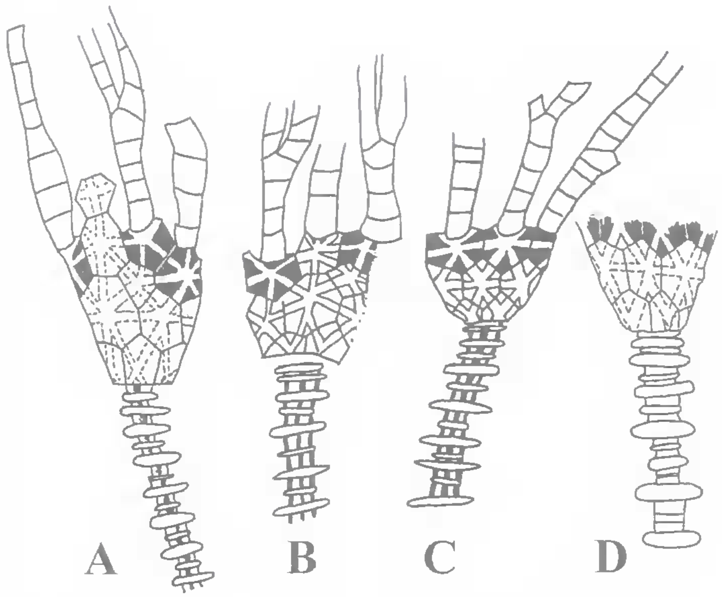


FIG. 70. *Holmesocrinus enidae* gen. et sp. nov., sketches of plate arrangements with radial ridge ornament shown on cup plates and radials black except for the radial ridges. A,B, NMVP100112 (Fig. 69C) and NMVP100102 (Fig. 69I), respectively, in posterior view showing pentagonal radianal. C, D, NMVP100107 (Fig. 69E) and NMVP100108 (Fig. 69H), respectively, in anterior view.

REMARKS. There is some variation in cup shape with those that are more narrowly conical also having almost knife-edged outer faces to arms. This suggests that there has been some degree of tectonic compression of those specimens but such distortion is not uniform in the echinoderms or the co-occurring brachiopods. There has been a certain amount of dislocation of cup plates in some specimens and the sutures are not clear on several specimens as they are deep in the recesses between ridges. Nevertheless sutures are readily determined by projecting the suture from where it crosses the ridge. There is some intraspecific variation in which brachials are axillary and also in the structure of the stem (order of columnals) but in general it is a uniform species. It is distinguished from all other plicodendrocrinids by the nature of its stem except for *H. idaensis* which has an unornamented cup.

Holmeseocrinus idaensis sp. nov.
(Fig. 71)

ETYMOLOGY. For Mount Ida, north of Heathcote, in the vicinity where the species occurs.

MATERIAL. HOLOTYPE: NMVP59256 (counterpart = NMVP148625). PARATYPE: 148623 from locality 52 of Thomas (see Talent, 1965, fig. 1), Parish of Redcastle, N of Heathcote, in clean orthoquartzite.

FIG. 69. *Holmesocrinus enidae* gen. et sp. nov., all crowns from NMVPL1923. A,F, C,D, part and counterpart of holotype NMVP100112, ×2, ×4, ×2 and ×4, respectively. B, NMVP100104, ×5. E, NMVP100107, ×2.5. G, NMVP107107, ×3. H, NMVP100108, ×5. I, NMVP100102, ×3.5.

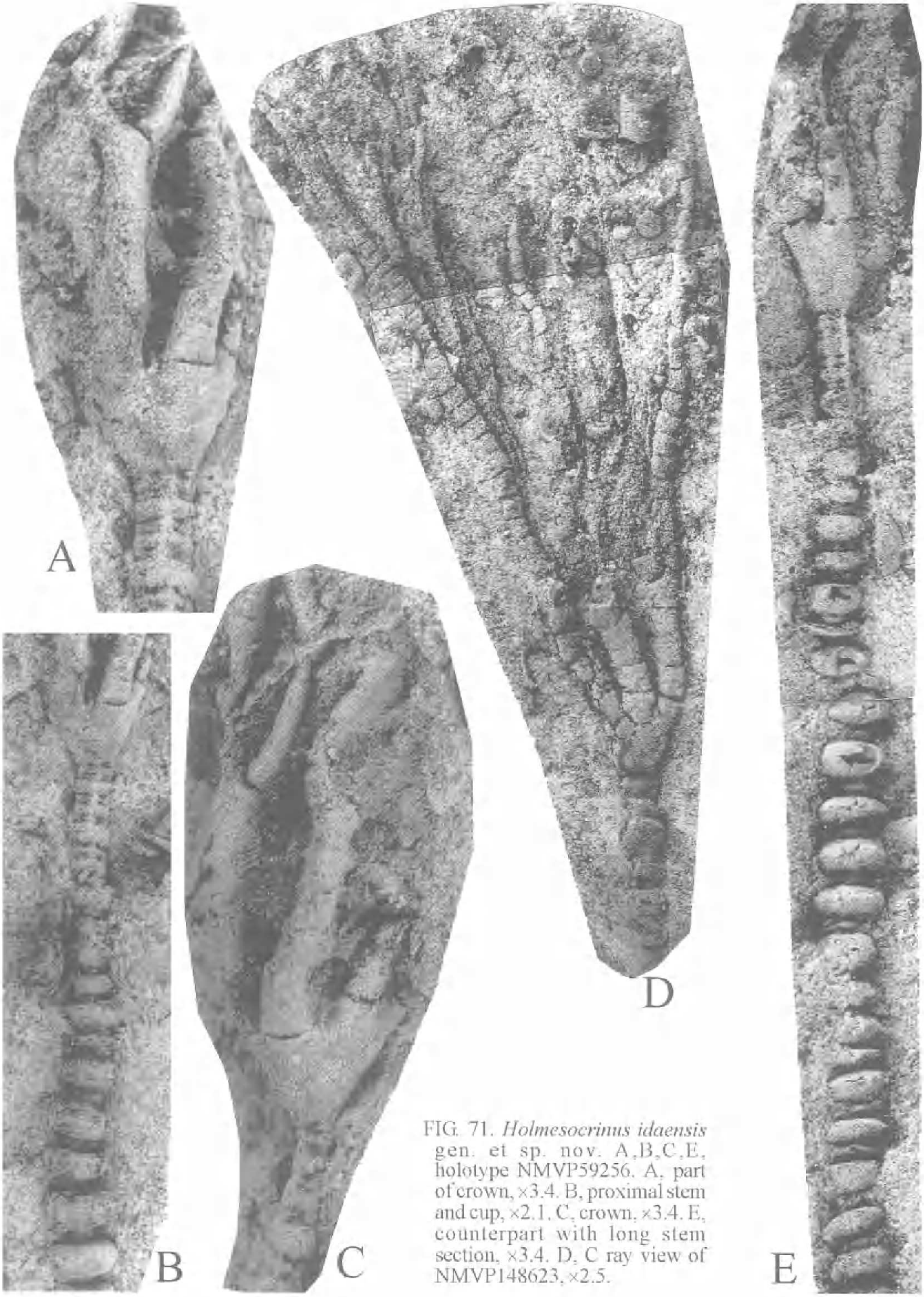


FIG. 71. *Holmesocrinus idaensis* gen. et sp. nov. A,B,C,E, holotype NMVP59256. A, part of crown, ×3.4. B, proximal stem and cup, ×2.1. C, crown, ×3.4. E, counterpart with long stem section, ×3.4. D, C ray view of NMVP148623, ×2.5.

DIAGNOSIS. Crown conical, 45mm long. Cup smooth, without radiating ridges. Stem with nodals barely wider than internodals proximally, becoming greatly enlarged distally with rounded latus.

DESCRIPTION. Cup low conical, as long as wide. Thecal plates thick, smooth, slightly depressed at corners. Infrabasals 5, pentagonal, as long as wide, upflared, fully visible laterally except for lower flange resting on stem, with central basal projection in line with angle of stem. Basals 5, about as long as wide; posterior basal 7-sided, supporting the anal X distally across a horizontal suture. Radials 5, pentagonal, as long as wide, largest plates in cup; radial facet, peneplenary to plenary, round, subhorizontal. Two anal plates in cup: radianal quadrate to rectangular, proximal and left of C radial; anal X in radial circlet, same shape as radials. Anal sac poorly preserved, with central posterior column of smooth plates, may be short slim and straight, mostly unknown. Arms isotomous, narrow, deep U-shaped cross section, dividing 3 times on 4th-6th brachial each time; brachials rectangular, nonpinnulate. Stem pentagonal in section proximally, heteromorphic, noditaxis N1, with nodals up to and sometimes more than twice as long as and slightly wider than internodals; distally internodals becoming exceptionally expanded, with rounded latus.

REMARKS. Generic assignment of this taxon depends heavily on stem structure which matches that of *H. enidae* very closely in having pentagonal internodals and greatly expanded circular nodals with priminternodals becoming circular distally. The difference in cup ornament could be considered a generic feature but this disparity is observed between congeneric species in other dendrocrinoid genera and so *Holmesocrinus* is considered best identified by the stem structure. As in *H. enidae* the radianal is proximal and left of the C radial, the radial facets are peneplenary and the arms branch isotomously.

Family THALAMOCRINIDAE Miller & Gurley, 1895

The family was broadly interpreted by McIntosh (1979) to include 13 genera but he (1983) later redefined the family more closely with 7 genera including 3 genera not included in 1979. In 1988 McIntosh & Brett recognised the priority of Thalamocrinidae and reorganised the family content once more. We acknowledge that classification of primitive cladids is far from settled at both familial and generic levels and thus retain the broader concept of the family.

Antihomocrinus Schmidt, 1934

TYPE SPECIES. *Homocrinus tenuis* Bather, 1893 from the Wenlock of Gotland, Sweden.

DIAGNOSIS. Cup high conical; thecal plates smooth, thick; 2 anal plates in cup; radianal quadrangular; anal sac straight, long, nonplicate; radial facets peneplenary; arms branching isotomously on first 2 divisions, third divisions may be at different heights in same ray; stem circular in section, heteromorphic proximally.

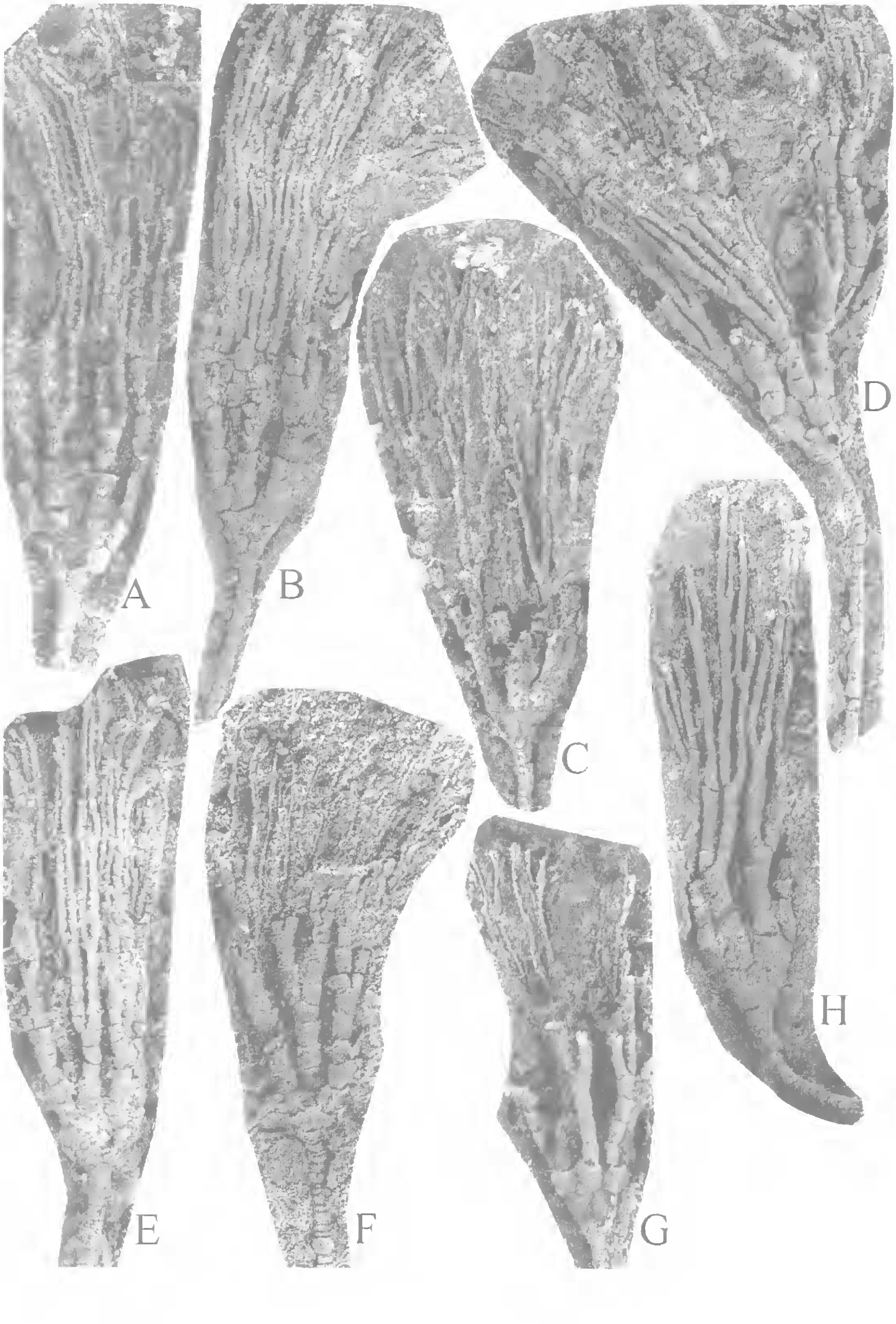
REMARKS. The type species has a round stem whereas other species assigned by Schmidt (1934, 1941) have pentagonal stems and may not belong to the same lineage. There is little to choose between *Bactrocrinites* and *Antihomocrinus* and indeed Schmidt's (1934) original diagnosis mentioned only that the infrabasals and basals of *Antihomocrinus* were more normally proportioned i.e. not elongate as in *Bactrocrinites*. The Australian species is assigned here on the basis that its cup plates are not nearly as elongate as in *Bactrocrinites* and its stem is round in section as opposed to pentagonal in *Bactrocrinites* (Schultze, 1867, pl. 5, fig. 1g).

McIntosh (1983) noted the only significant distinction between the type species of *Antihomocrinus* and *Lasiocrinus* Kirk, 1914 as the isotomous vs. heterotomous arm branching, respectively. The new Australian species has isotomous arm branching in the lower 2 divisions but the 3rd divisions, in many cases, are at different heights in the same arm. In at least one specimen (Fig. 75A-C) the arms branch isotomously but the branches nearest to the central axis of the ray form 2 straight vertical columns and all lateral branches move asymmetrically away from the central axis. These features could be regarded as beginning to evolve from isotomous towards heterotomous arms and thus intermediate between the 2 genera. I place the new species in *Antihomocrinus* because the arm branching comes closer to the isotomous condition.

Antihomocrinus chapmani sp. nov.
(Figs 72-77)

ETYMOLOGY. For Frederick Chapman, for his contribution to Victorian Palaeozoic faunal studies.

MATERIAL. HOLOTYPE: NMVP108630. PARATYPES: NMVP100170, 108606, 108612, 108616, 108631, 108632, 108639, 108648, 108687, 109769,


A
B
C
D
E
F
G
H

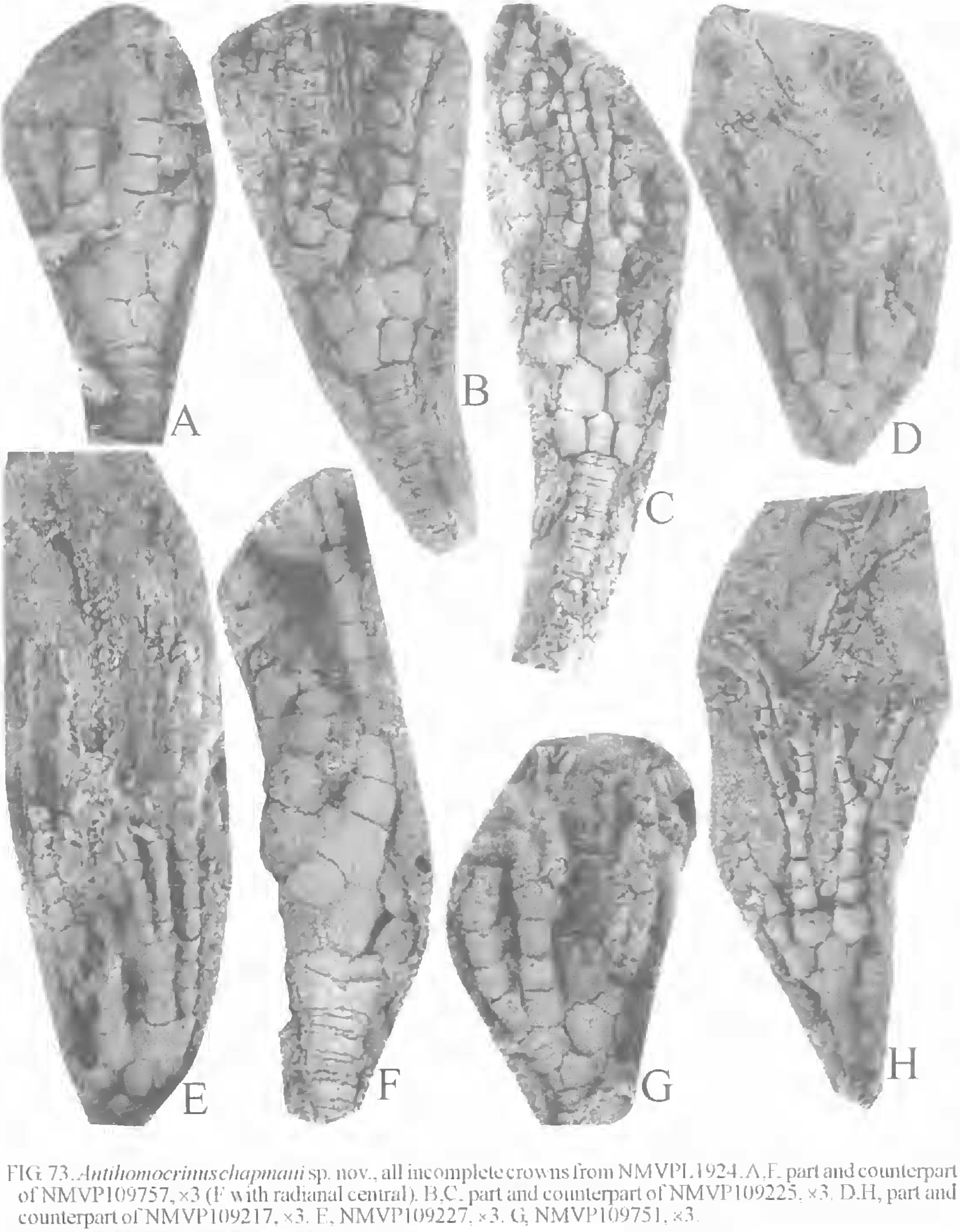


FIG. 73. *Antihomocrinus chapmani* sp. nov., all incomplete crowns from NMVPL1924. A,F, part and counterpart of NMVP109757, ×3 (F with radianal central). B,C, part and counterpart of NMVP109225, ×3. D,H, part and counterpart of NMVP109217, ×3. E, NMVP109227, ×3. G, NMVP109751, ×3.

FIG. 72. *Antihomocrinus chapmani* sp. nov., all crowns in lateral view from NMVPL300. A, NMVP149369, ×2.7. B, NMVP109797, ×2.7. C, NMVP109792, ×2.7. D, C ray view of NMVP109770, ×2.7. E, NMVP110625, ×2.7. F, NMVP149370, ×2.7. G, NMVP149371, ×2.7. H, NMVP109799, ×2.7.

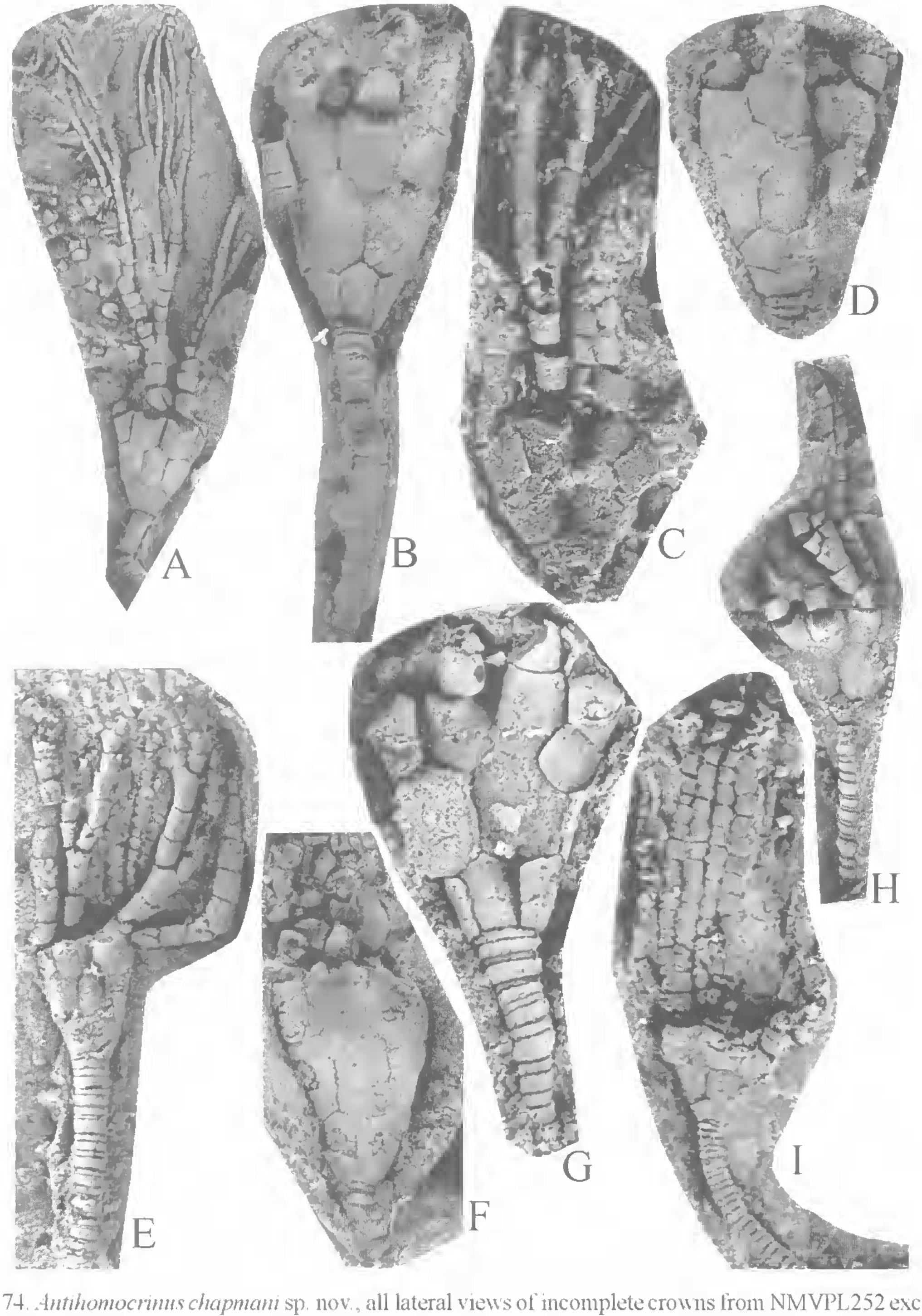


FIG. 74. *Antihomocrinus chapmani* sp. nov., all lateral views of incomplete crowns from NMVPL252 except F from Chirnside Park (NMVPL1922). A, anterior view of crown NMVP109769, ×2.4. B,D, part and counterpart of cup NMVP108616, ×2.4. C, posterior view including part of anal tube of NMVP149360, ×2.4. E, anterior view of crown with anal tube evident NMVP149372, ×2.4. F, cup NMVP107090, ×2.4. G, D ray view of cup NMVP108687, ×2.4. I, anterior view of crown with anal tube but no arms preserved NMVP149361, ×3.2. H, *Dictenocrinus ibaeypus* sp. nov., anterior view of crown NMVP108612, ×2.5.

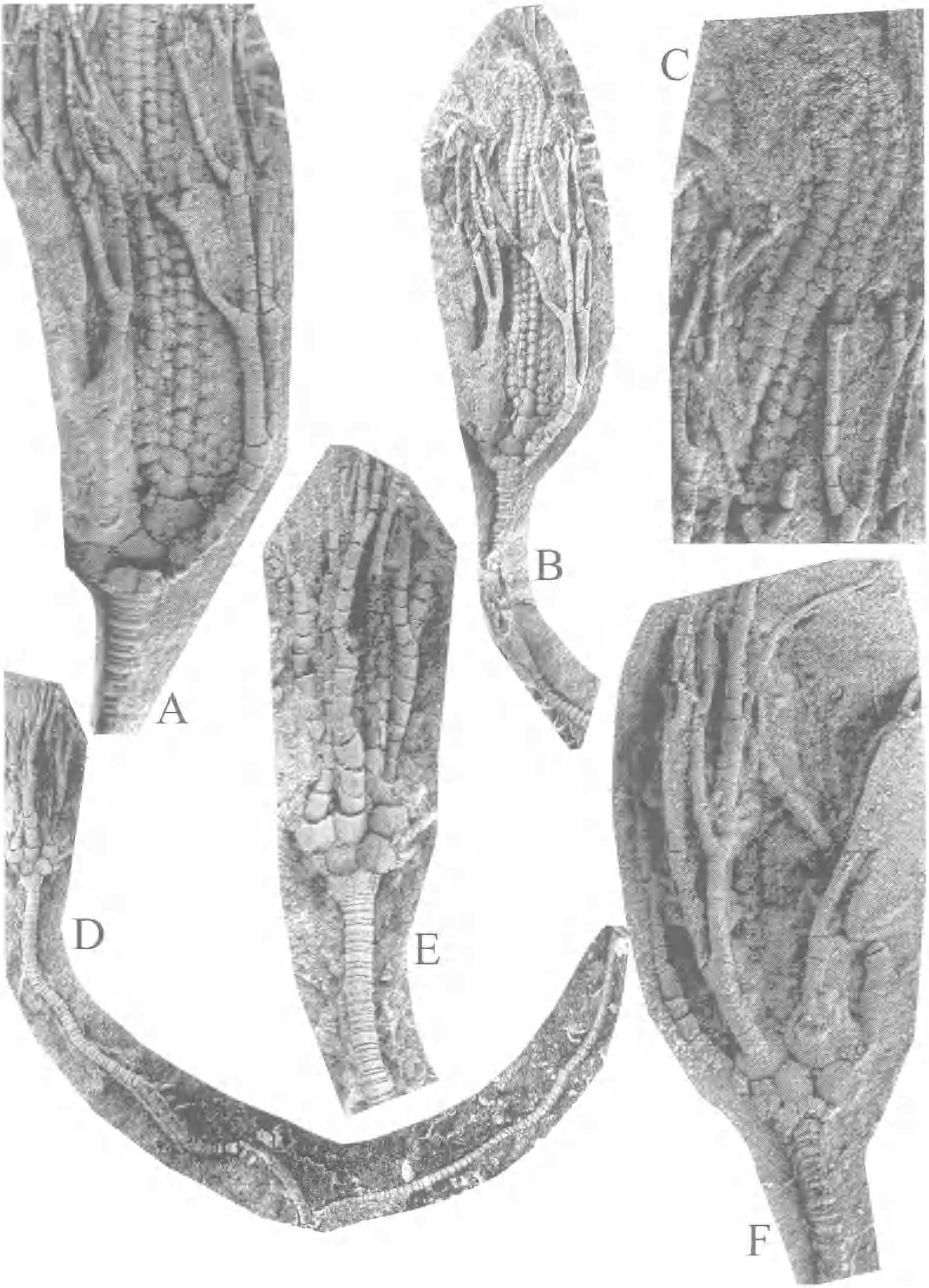


FIG. 75. *Antihomocrinus chapmani* sp. nov., all crowns in lateral view from NMVPL252. A-C, F, holotype crown NMVP108630. A,B,C, posterior view, ×5, ×2 and ×5, respectively. C, distal anal tube. F, anterior view, ×5. D,E, D ray view of NMVP108632, ×2.5 and ×4, respectively. E showing crushed anal tube.

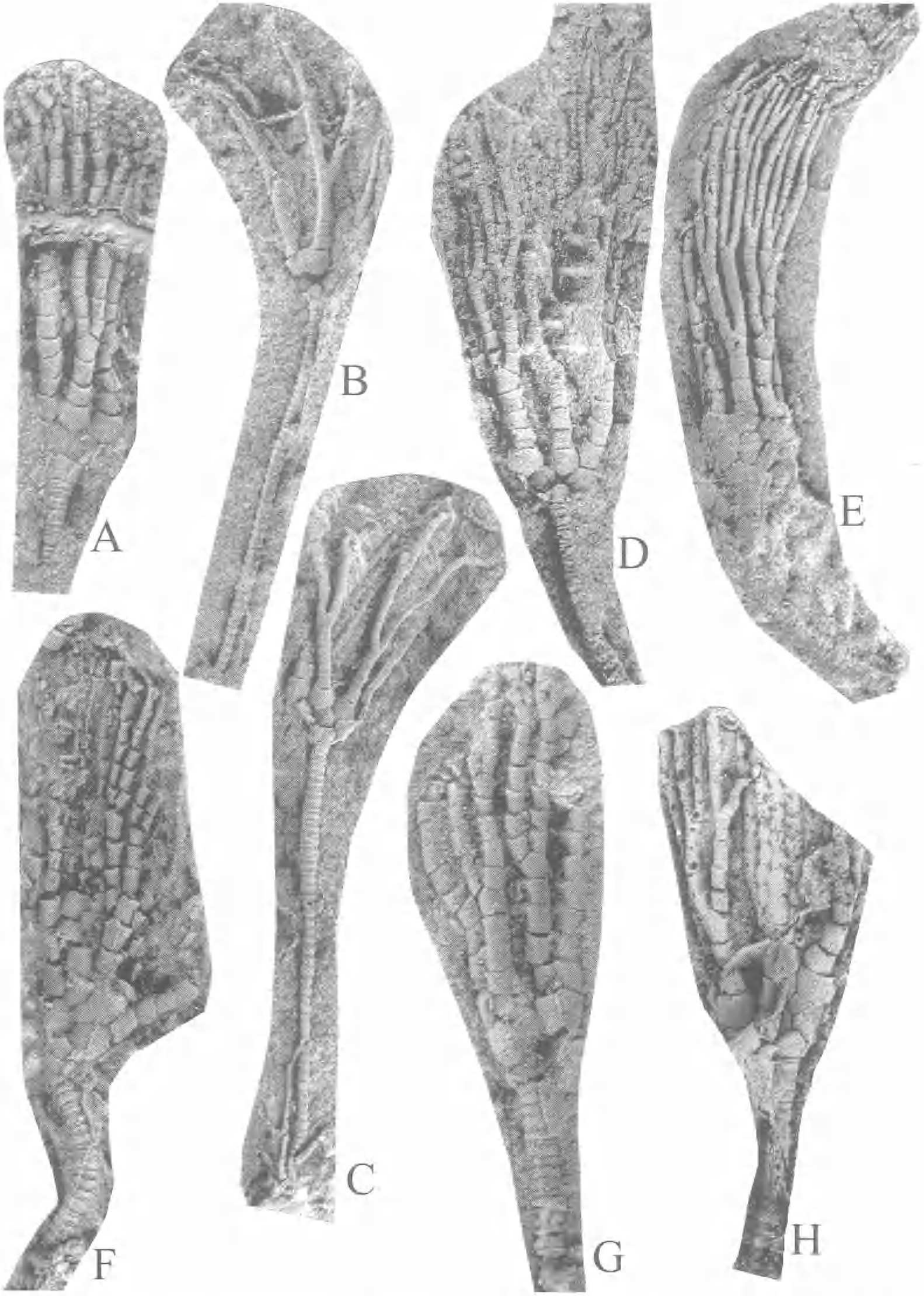


FIG. 76. *Antihomocrinus chapmani* sp. nov., all crowns from NMVPL252. A, NMVP108632, ×3. B,C, part and counterpart of NMVP108639, ×3. D, NMVP108631, ×3. E, NMVP108648, ×3. F, NMVP112131, ×3. G, NMVP100170, ×3. H, NMVP108606, ×3.

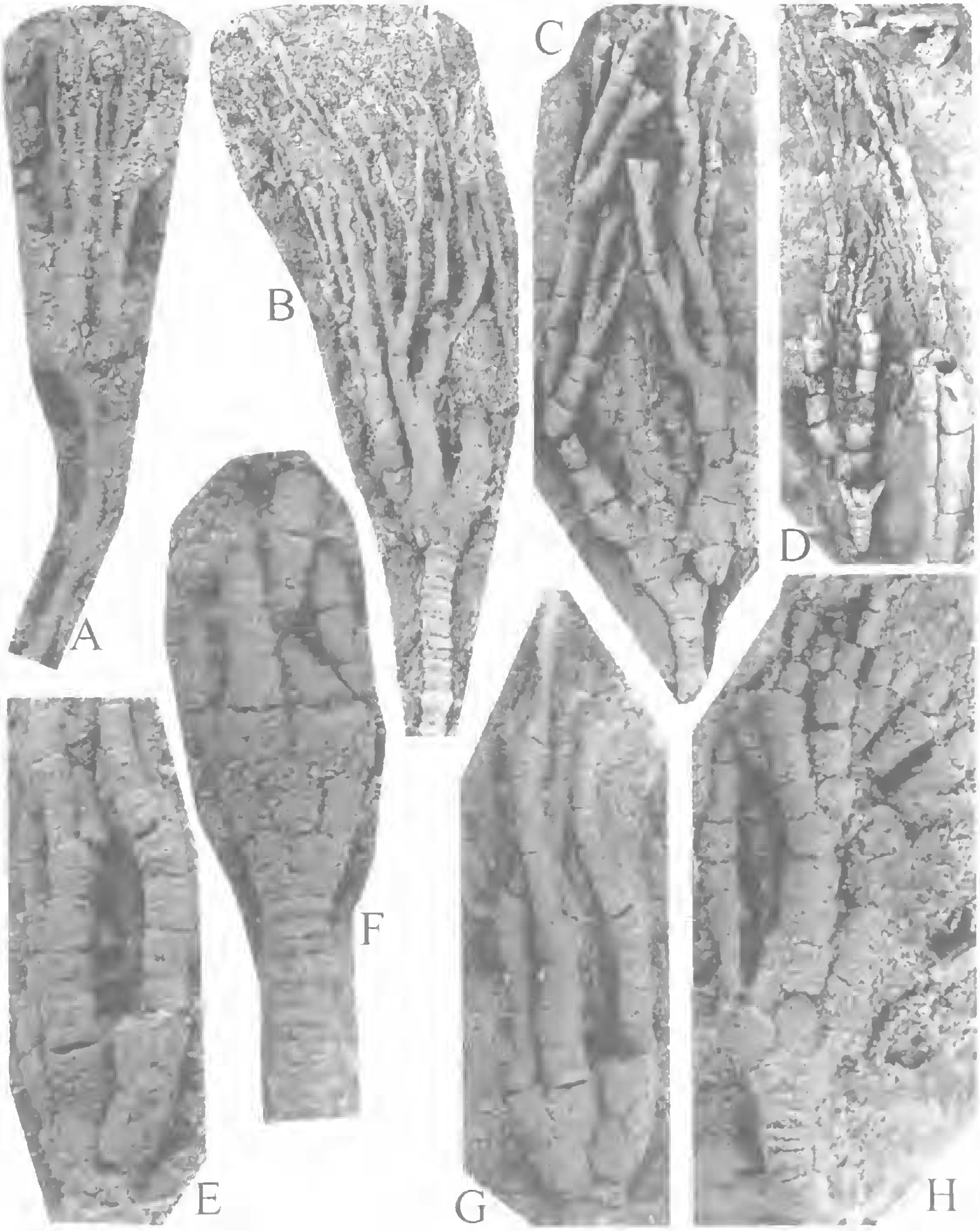


FIG. 77. *Antihomocrinus chapmani* sp. nov., all crowns or partial crowns from NMVPL 229. A, NMVP108688, ×3. B, NMVP109157, ×3. C,D, part and counterpart of NMVP100167, ×3 and ×2, respectively. E-G, NMVP100154, ×5, ×5 and ×3, respectively. H, NMVP108953, ×3.

112131, 149360, 149361, 149372 from NMVPL252. NMVP109217, 109225, 109227, 109751, 109757 from NMVPL1924; NMVP107090 from Chirnside Park Estate, Lilydale. NMVP100154, 100167, 108688, 108953, 109157 from NMVPL229; NMVP109770, 109792, 109797, 109799, 110625, 149369-149271 from NMVPL300.

DIAGNOSIS. Cup high conical. Infrabasals almost as long as basals. Radial facets angustary. Arms uniserial, branching isotomously up to 4 times. Anal tube long, with curved tip, of vertical columns of smooth (smaller specimens) to radially ornamented polygonal plates. Stem circular in section, heteromorphic, becoming uniform distally; nodals longer but only slightly wider than alternating internodals.

DESCRIPTION. Crown 30mm long, subcylindrical to subconical with distal arms flaring slightly. Cup conical, longer than wide. Thecal plates thick, smooth. Infrabasals 5, pentagonal, from 0.5 up to twice as long as wide, upflared, fully visible laterally except for lower flange resting on stem. Basals 5, same size or larger than radials, longer than wide; posterior basal 7-sided, supporting the radianal distally and slightly to the right across an oblique suture, with distal sutural margin supporting anal X not quite horizontal. Radials 5, pentagonal, as long as wide; radial facet, peneplenary, round, subhorizontal, not declined. Anal plates in cup 3; radianal quadrate, proximal and left of C radial; anal X in radial circlet, same shape as but slightly smaller (i.e. not extending as far distally) than radials; proximal part of 3rd anal plate below distal margin of C radial. Anal sac long, of vertical columns of small smooth hexagonal plates, with plates in alternate columns bearing stellate ornament in larger individualals (merely depressed corners in smaller individuals), with curved tip. Arms isotomous, almost circular in cross section, dividing 3 or 4 times on 3rd-5th primibrach, 3rd or 5th secundibrach and on 7th tertibrach, uniserial with rectangular brachials throughout, with deep V-shaped furrow on inner side, nonpinnulate, with 1st and 2nd divisions always at same level but with other divisions sometimes at different levels in same arm. Stem circular in section, noditaxis N1, with nodals up to and sometimes more than twice as long as and slightly wider than internodals, with fine central canal.

REMARKS. I initially separated this material into 3 species based on relative sizes of infrabasals to basals, numbers of primibrachs per arm, width of the radial facet and relative sizes of the radianal. Although there is some consistency of the variation in these features between localities there are numerous exceptions and I think it more likely the collections from different localities represent variable populations (the variants in different proportions) of a long ranging (Ludlow to Lochkovian) species. A large number of illustrations are provided to show the variation as much as possible.

It differs from the German species in its round rather than pentagonal stem and from the type species by the stellate ornament on anal tube and heteromorphic stem but it is close to the type.

Ancyrocrinus Hall, 1862

TYPE SPECIES. *Ancyrocrinus bulbosus* Hall, 1862 from the Middle Devonian of New York.

Ancyrocrinus sp.
(Fig. 78)

MATERIAL. NMVP107105 from NMVPL229.

DESCRIPTION. Cup cylindrical, as long as wide. Thecal plates smooth. Infrabasals 5, pentagonal, wider than long, upflared, fully visible laterally except for lower flange resting on stem. Basals 5, largest plates in cup, only slightly longer than wide; posterior basal 7-sided, supporting the anal X distally across a horizontal suture. Radials 5, pentagonal, as long as wide; radial facet peneplenary, round, declivate. Two anal plates in cup: radianal quadrate, proximal and left of C radial; anal X in radial circlet, similar size and shape to radials. Anal sac tall, of smooth polygonal plates. Arms almost circular in cross section, with deep U-shaped furrow on inner side, with 3rd primibrach axillary, uniserial with rectangular brachials throughout. Stem rounded subquadrate or subpentagonal in section, heteromorphic, with nodals much longer and slightly wider than internodals.

REMARKS. This incomplete specimen is assigned to *Ancyrocrinus* based on cup shape, shape position and size of radianal and shape of the stem. The most distinctive feature of the genus, the grapnelhook termination to the stem has not been found at this locality but other features are sufficient for assignment. It is left in open nomenclature because it is incomplete and a single specimen.

Nassoviocrinus Jaekel, 1918

TYPE SPECIES. *Heterocrinus pachydactylus* Sandberger & Sandberger, 1855 from the Lower Devonian of Germany.

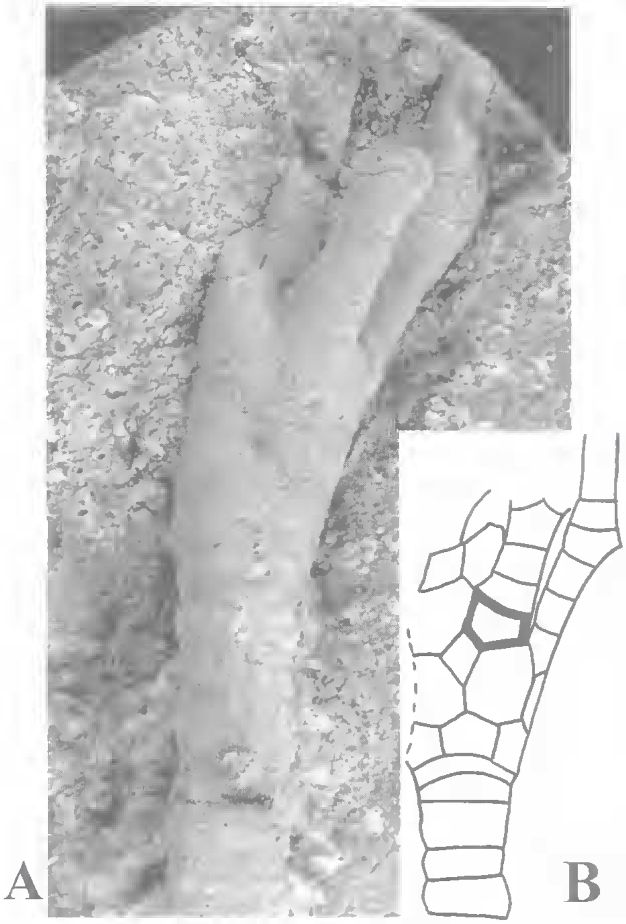


FIG. 78. *Ancyrocrinus* sp. A, crown with incomplete arms NMVP107105 from NMVPL229, ×4. B, sketch showing posterior plate arragement (C radial heavily outlined).

DIAGNOSIS. Cup low conical; thecal plates with or without ornament; radianal quadrangular; radial facets angustary to peneplenary; anal sac long, straight, of regular columns of small plicate plates; arms isotomous, branching 3 or more times; stem pentagonal, heteromorphic.

REMARKS. McIntosh (1983) reviewed this genus assigning 6 species from the Lower and Middle Devonian of Europe and North America. These Australian Ludlow species are assigned by comparison with the type species with which they share the pentagonal heteromorphic stem, quadrangular radianal, isotomous arms and general shape and proportions of the cup. Although *N. longibrachiatus* has perfectly smooth thecal plates unlike European representatives, the depressed corners of thecal plates in *N. corcorani* are comparable with other members of the genus.

Nassoviocrinus longibrachiatus
(Chapman, 1903) (Fig. 79)

Botryocrinus longibrachiatus Chapman, 1903:108, pl. 18, figs 6-8.

MATERIAL. LECTOTYPE (designated here) NMVP390 & 392 (part and counterpart) from NMVPL1615. Other material NMVP109174, 109176 from NMVPL1615 and NMVP109177-109179 from the Upper Yarra.

DIAGNOSIS. Cup low conical; thecal plates smooth, unornamented; radial facet peneplenary; radianal quadrangular; anal X supporting 3 anal plates distally; anal tube long, straight, of vertical columns of plicate plates; arms branching isotomously, at least 3 times; stem pentastellate in section, heteromorphic.

DESCRIPTION. Crown subcylindrical, 35mm long. Cup low conical, wider than long. Thecal plates smooth, without ridges. Infrabasals 5, pentagonal, wider than long, with lateral basal corners projecting slightly where they extend onto the projections in the stem. Basals 5, hexagonal, longer than wide, largest plates in cup; posterior basal with 7th side on distal margin, supporting anal X distally. Radials 5, pentagonal, wider than long; radial facet angustary to peneplenary, subcircular, with deep ventral groove. Anal plates in cup 2; radianal quadrangular, proximal and left of C radial, with diagonals horizontal and vertical; anal X heptagonal, wider than long, in radial circlet, supporting 3 plates at base of anal sac. Anal sac long, narrow, straight, of plates with radial ridges (2 in each direction laterally and 1 each distoproximally) arranged in vertical columns, with larger proximal central plate having ridges only near upper margin, with lateral basal plates much smaller than central one. Arms isotomous, branching at least 3 times, deep U-shaped in section (i.e. laterally compressed), with deep groove on inner side; primibrach 4 axillary except in A ray where 5th primibrach is axillary; axillary secundibrach variable 6-8. Stem pentastellate, heteromorphic, noditaxis N212.

REMARKS. This species is assigned to *Nassoviocrinus* on the basis of its quadrangular radianal.

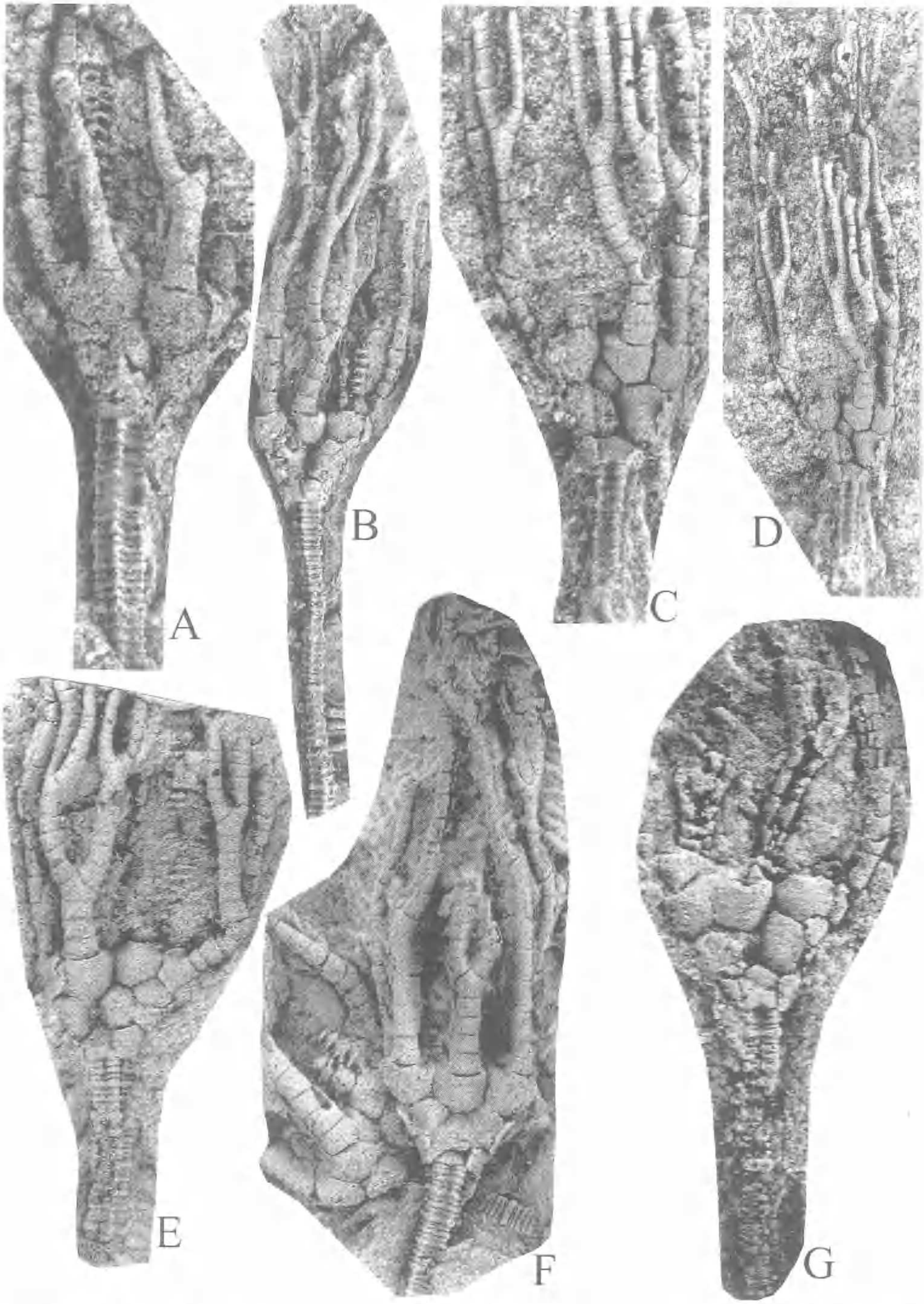


FIG. 79. *Nassoviocrinus longibrachiatus* sp. nov., all lateral views of crowns; A,B,F from Upper Yarra; C,D,E,G from NMVPL1615. A, NMVP109177, ×4. B, D ray view of NMVP109179, ×3. C,D, posterior view of NMVP109176, ×4 and ×2.5, respectively. E, posterior view of NMVP109174, ×4. F, two crowns overlying each other NMVP109178, ×2.5. G, posterior view of holotype with inner side of A and B ray arms exhibiting deep groove, NMVP390, ×3.

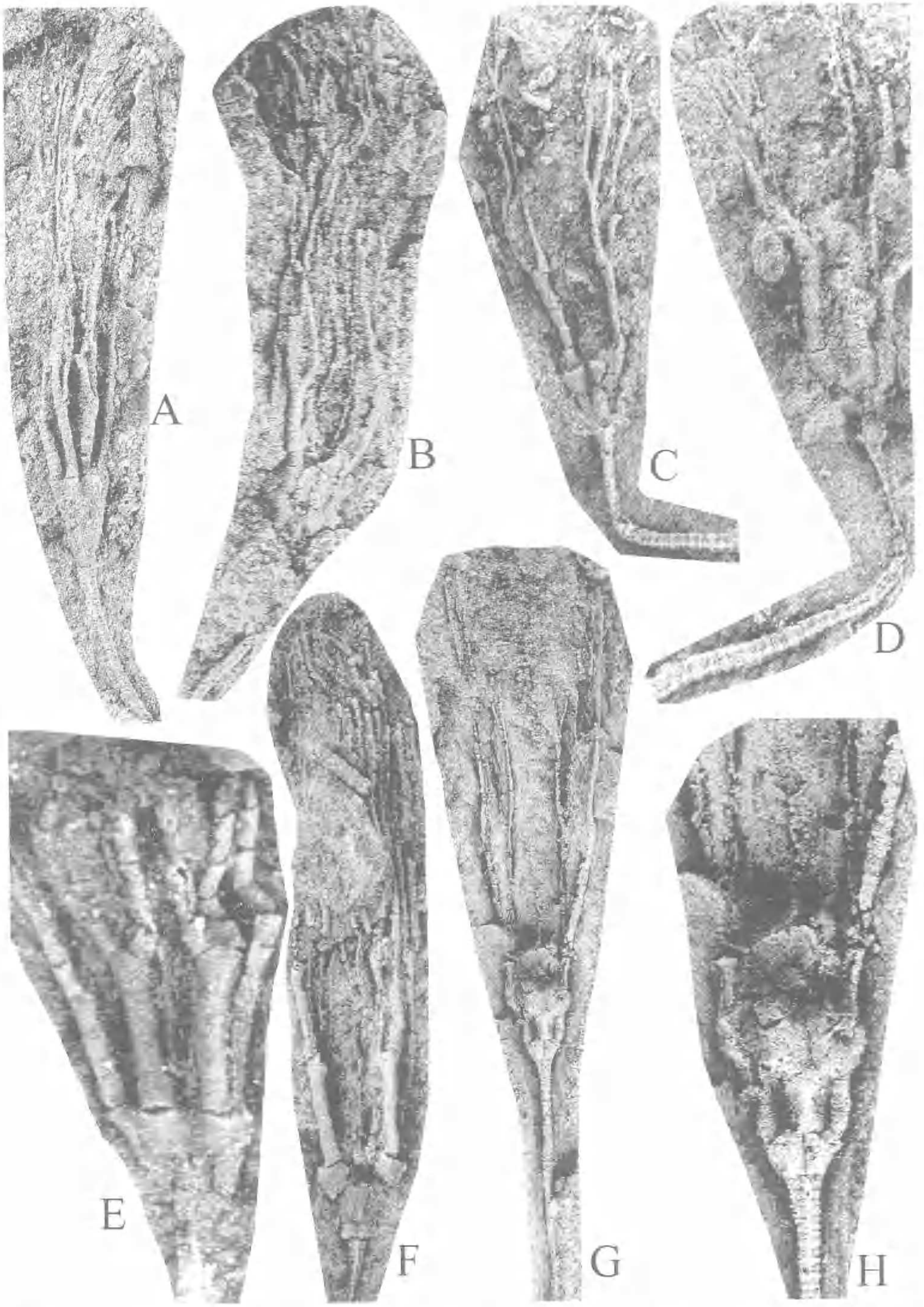


FIG. 80. *Nassoviocrinus corcorani* sp. nov all crowns in lateral view; A,G,H from NMVPL299; B-F, from NMVPL2259. A, NMVP109207, ×3. B, NMVP59498, ×7. C,D, part and counterpart of holotype NMVP109202, ×4 and ×5, respectively. E, NMVP149363. F, NMVP109199, ×7. G,H, NMVP148575, ×2 and ×4, respectively.

pentastellate stem, isotomous arm branching and peneplenary radial facets. It is distinguished from the type and other species of the genus by having unornamented thecal plates.

This, along with *N. corcorani*, is the first record of the genus from the Silurian and the depressed corners of thecal plates in the latter species indicate that the main lineage with thecal ornament began before the Ludlow and that *N. longibrachiatus* was an early offshoot that evolved a smooth theca.

Nassoviocrinus corcorani sp. nov.
(Fig. 80)

Class Crinoidea Talent, 1965:17, pl. 4, fig. 2.

ETYMOLOGY. For Peter Corcoran of Sandringham, Melbourne who contributed material to this study.

MATERIAL. HOLOTYPE: NMVP109202 from NMVPL2259. PARATYPES: NMVP59498, 109199, 149363 from NMVPL2259; NMVP109207, 148575 from NMVPL299.

DIAGNOSIS. Cup high conical; thecal plates with broad low ridge ornament leaving corners of plates depressed; radial facet peneplenary; radianal quadrangular; arms branching isotomously, at least 3 times; stem pentagonal in section, heteromorphic.

DESCRIPTION. Crown 20mm long, subcylindrical. Cup high conical, longer than wide. Thecal plates with 2 broad low ridges running diagonally distally from the basal corners of infrabasals to cross on infrabasals and basals and then meet another such ridge at the base of the radial facet. Infrabasals 5, pentagonal, longer than wide, with lateral proximal corners projecting slightly where they extend onto the projections in the stem. Basals 5, hexagonal, longer than wide, largest plates in cup. Radials 5, pentagonal, longer than wide; radial facet peneplenary, subcircular, horizontal or almost so. Anal plates in cup 2; radianal quadrangular, proximal and left of C radial; anal X longer than wide, in radial circlet. Anal sac unknown. Arms isotomous, branching at least 3 times, deep U-shaped in section (i.e. laterally compressed), with deep groove on inner side; primibrach 5 or 6 axillary; 2nd and 3rd branchings may be at different levels in same arm. Stem pentagonal, noditaxis N212, with alternating long nodals and short internodals.

REMARKS. This species is distinguished by its high conical cup although plate boundaries are poorly defined in some specimens, its broad low ridge ornament, its quadrangular radianal, peneplenary horizontal radial facets and its pentagonal stem of very small diameter. It is a much smaller species than others in the genus and has a taller cup but its stem and posterior interray are quite compatible with *Nassoviocrinus*.

Dictenocrinus Jaekel, 1918

TYPE SPECIES. *Botryocrinus decadactylus* Bather, 1891 from the Upper Silurian of England.

Dictenocrinus ibaeypus sp. nov.
(Fig. 81)

ETYMOLOGY. Ib = infrabasal and Greek *aipys*, tall.

MATERIAL. HOLOTYPE: NMVP108612. PARATYPES: NMVP108624, 108635, 108649, 108657, 108680, 108682, 149373 from NMVPL252.

DIAGNOSIS. Cup high conical; thecal plates smooth; infrabasals long, longer than wide; radial facets peneplenary, horizontal; radianal quadrangular; anal tube tall, straight, of smooth hexagonal plates; arms 10, isotomous, pinnulate, with 3rd or 4th primibrach axillary; stem circular in section, heteromorphic.

DESCRIPTION. Crown subcylindrical, 35mm long. Cup high conical, longer than wide. Thecal plates smooth. Infrabasals 5, pentagonal, upto twice as long as wide, only gently upflared, fully visible laterally except for lower flange resting on stem. Basals 5, largest plates in cup, twice as long as wide; posterior basal 7-sided, supporting the anal X distally and slightly to the right across a slightly oblique suture. Radials 5, pentagonal, as long as wide; radial facet, peneplenary, round, subhorizontal, not declined. Two anal plates in cup: radianal quadrangular, proximal and left of C radial; anal X in radial circlet, same size and shape as radials, distal edge distal to top of D radial but same level as top of C radial. Anal sac long, of alternating vertical columns of small smooth plates, tip unknown. Arms isotomous, deep, narrow, U-shaped cross section, dividing only once on 3rd or 4th primibrach, uniserial with rectangular brachials in proximal parts becoming slightly cuneate distally, with deep V-shaped furrow on inner side, with long fine pinnules one per brachial alternating from side to side up each arm, pinnules apparently absent from primibrachs including axillary. Stem circular in section, noditaxis N1, with nodals at least twice as long as and slightly wider than internodals, with fine central canal.

REMARKS. Within the genus the length of the infrabasals coupled with smooth anal plates and

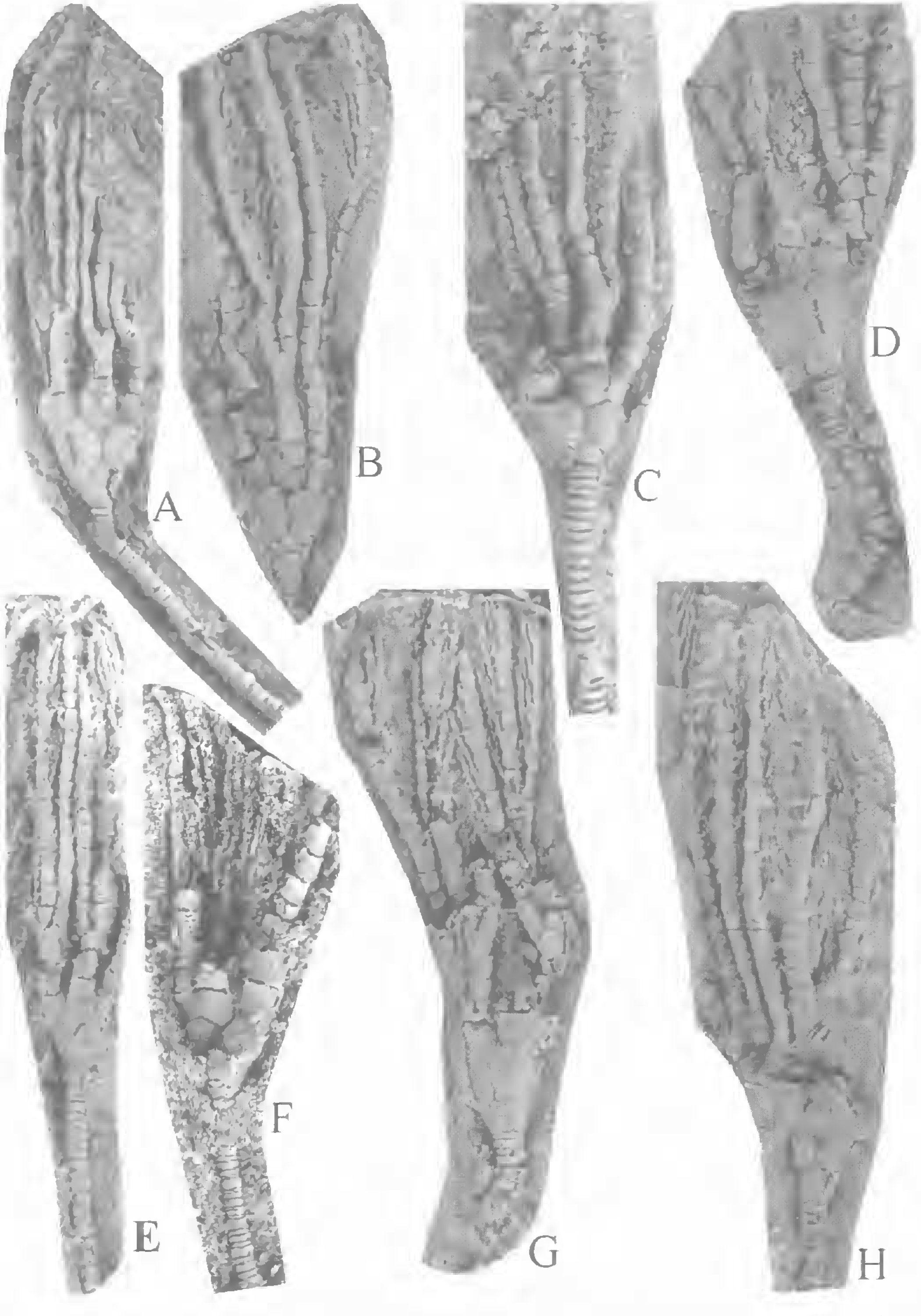


FIG. 81. *Dictenocrinus ibaeypus* sp. nov., all lateral views of crowns from NMVPL252. A, NMVP108657, ×3. B, NMVP149373, ×3. C, NMVP108624, ×3. D, posterior view of holotype NMVP108612, ×3. E, NMVP108682b, ×3. F, NMVP108680, ×3. G, NMVP108635, ×3. H, NMVP108649, ×3.

round stem separate all except *D. cyathiformis* (Haarmann, 1921). *D. cyathiformis* is only distinguished by its stem having uniform columnals and expanding proximally to base of cup, by its anal X being 6-sided and by its shorter pinnules.

Dictenocrinus remotus sp. nov.
(Fig. 82B)

ETYMOLOGY. Latin *remotus*, distant: the material was collected a long way from where it occurred because the material was excavated at Coldstream West Road and taken down Mooroolbark Road to fill a large depression.

MATERIAL. HOLOTYPE: NMVP149374 from NMVPL1990.

DIAGNOSIS. Low conical cup, of convex plates: radial facets peneplenary; anal tube tall, of plicate plates; radianal subquadrate, proximal and left of C radial; arms heterotomous, with one main division in each ray on axillary 3rd primibrach, with long nonpinnulate ramules on every 3rd or 4th brachial distal to the first division; stem pentagonal in section, heteromorphic.

DESCRIPTION. Crown subcylindrical, 35mm long. Cup low conical, as long as wide. Thecal plates convex, smooth. Infrabasals 5, pentagonal, short (slightly wider than long), fully visible laterally. Basals 5, large, hexagonal; posterior basal 7-sided, supporting the anal X distally. Radials 5, pentagonal, as long as wide; radial facet, peneplenary, round, declivate at very low angle. Two anal plates in cup; radianal subquadrate, proximal and left of C radial; anal X in radial circlet, same size and shape as radials, distal margin in line with distal margin of C and D radials. Anal sac tall, of vertical columns of small plicate plates, tip unknown. Arms heterotomous, with narrow, U-shaped cross section, with one main division at 3rd primibrach, uniserial with long rectangular brachials proximally becoming slightly cuneate distally, with long nonpinnulate ramules on every 3rd or 4th brachial distally. Stem pentagonal in section, heteromorphic, with noditaxis N3231323.

REMARKS. Although known from only one specimen this species has the single main division of ramulate arms and pentagonal stem found in the type species (Bather,1891) from which it is distinguished by the plicate anal tube and peneplenary radial facets.

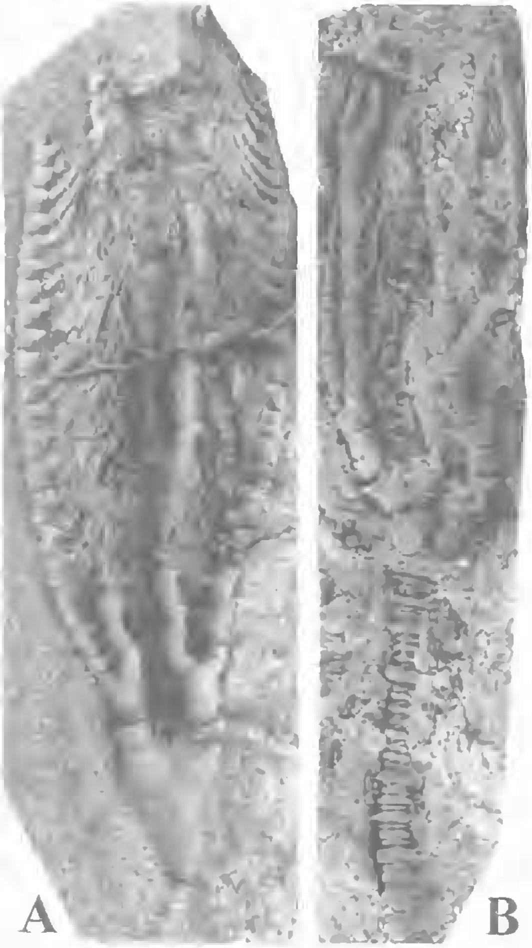


FIG. 82. A, *Dictenocrinus* sp. cf. *D. ibaeypus* sp. nov., anterior lateral view of crown NMVP107058 from a road cutting on the road to Wonga Park, east of Melbourne, ×3. B, *Dictenocrinus remotus* sp. nov. posterior view of crown NMVP149374 from NMVPL1990 (although collected from spoil heap on Mooroolbark Road), ×3

Dictenocrinus sp. cf **D. ibaeypus** sp. nov.
(Fig. 82)

MATERIAL. NMVP107058 from a road cutting on the road to Wonga Park in eastern Melbourne.

DESCRIPTION. Crown subcylindrical, 40mm long. Cup high conical, longer than wide. Thecal plates smooth. Basals largest plates in cup, twice as long as wide. Radials 5, pentagonal, as long as wide; radial facet angustary, round, subhorizontal. Arms isotomous, U-shaped cross section, dividing once on 3rd or 4th primibrach, uniserial, with rectangular brachials proximally becoming cuneate distally, with long fine pinnules 1 per brachial alternating from side to side along each arm, pinnules apparently absent from primibrachs including axillary. Stem not known.

REMARKS. This specimen differs from *D. ibaeypus* in its radial facet being more angustary than peneplenary and in its secundibrachs being cuneate. Without knowledge of the posterior interradius it is not possible to assign this specimen with certainty but if the posterior was identical with *D. ibaeypus* the variations noted above might well be considered to be intraspecific variation particularly since the 2 populations represented occurred some 40-50km apart.

Subclass FLEXIBILIA Zittel, 1895
Order TAXOCRINIDA Springer, 1913
Family TAXOCRINIDAE Angelin, 1878

Meristocrinus Springer, 1906

TYPE SPECIES. *Taxocrinus loveni* Wachsmuth & Springer, 1880 (=*Cyathocrinus interbrachiatus* Angelin, 1878) from the Upper Silurian of Gotland, Sweden; by original designation.

Meristocrinus quatriramus sp. nov.
(Fig. 83)

ETYMOLOGY. Latin *quatri-*, four and *ramus*, branch; for the 4 branchings of each arm.

MATERIAL. HOLOTYPE: NMVP109765 from NMVPL1924.

DIAGNOSIS. Infrabasals evident laterally anteriorly but not posteriorly. C ray with radianal in inferoradial position. Arms branching 4 times. Stem of uniform diameter, proximally of short uniform plates becoming heteromorphic distally.

DESCRIPTION. Crown inverted pear-shaped, 60mm long. Cup small, low bowl-shaped, flaring strongly. Infrabasals visible in lateral view as short circlet with low peaks at 3 way junctions with 2 adjoining basals, number not determinable, may be fused. Basals 5, hexagonal, in AB and probably CD and DE interrays, pentagonal in AE and probably BC interrays, with short vertical sides, with highly obtuse or no basal angle and upper angle of 90°; CD basal irregular, with projection extending distally between D radial and radianal, with radianal in inferoradial position beneath C ray. Radials pentagonal, with plenary facets. Arms long, isotomous, expanding above radials, branching on primibrach 3, secundibrach 4, tertibrach 5 and quaternibrach 6, without interprimibrachs but with single pentagonal intersecundibrach (visible from inner side of arms), wide shallow groove on inner surface becoming deeper and occupying more of the arm width distally. Stem circular in section, widest proximally, of short, strongly crenulate columnals proximally, becoming heteromorphic distally with nodals and internodals alternating in length but uniform in diameter.

REMARKS. The posterior interray is not well preserved and is apparently distorted. The radianal is interpreted to be beneath the C radial and is drawn (Fig. 83B) as it appears as 2 separate pieces but this is probably due to preservation. More distal anal plating is very unclear. Among the 5 species recognised in this genus only *M. tuberosus* Springer, 1920 from the Wenlock of Gotland has arms that divide 4 times but it has only 3 secundibrachs as opposed to 4 in this Australian species.

Quadritaxocrinus gen nov.

TYPE SPECIES. *Quadritaxocrinus websteri* sp. nov.

ETYMOLOGY. Latin *quadri-*, four and generic name *Taxocrinus*.

DIAGNOSIS. Cup small; infrabasals not visible in lateral view; primibrachs 4; arms branching isotomously at 1st division, with 3rd divisions on inner branches at same level and those on outer branches at same level but more distal than on inner branches; stem circular in section, of short columnals proximally.

REMARKS. This genus compares closely with *Taxocrinus* in the infrabasals concealed by the stem, the wide posterior basal extending up between the C and D radials, shape of the axillary brachials and the lipped interbrachial articulations. Among Taxocrinidae the number of primibrachs is consistent at the generic level. *Taxocrinus*, with which *Quadritaxocrinus* is most closely allied, has 3 primibrachs and I suggest that evolution from the former to the latter in the Lower Devonian involved introduction of an extra primibrach. Ubaghs (1978a) pointed out that all Ordovician and Silurian, most Devonian and some Carboniferous genera have 2 primibrachs and from the Carboniferous on 3 is the standard number. More than 3 primibrachs are known in some species of *Onychocrinus* (Synerocrinidae) but that genus has entirely different arms from the new Australian taxon. The obvious inference is that the number of primibrachs increases with evolution in the flexible crinoids so evolution to 4

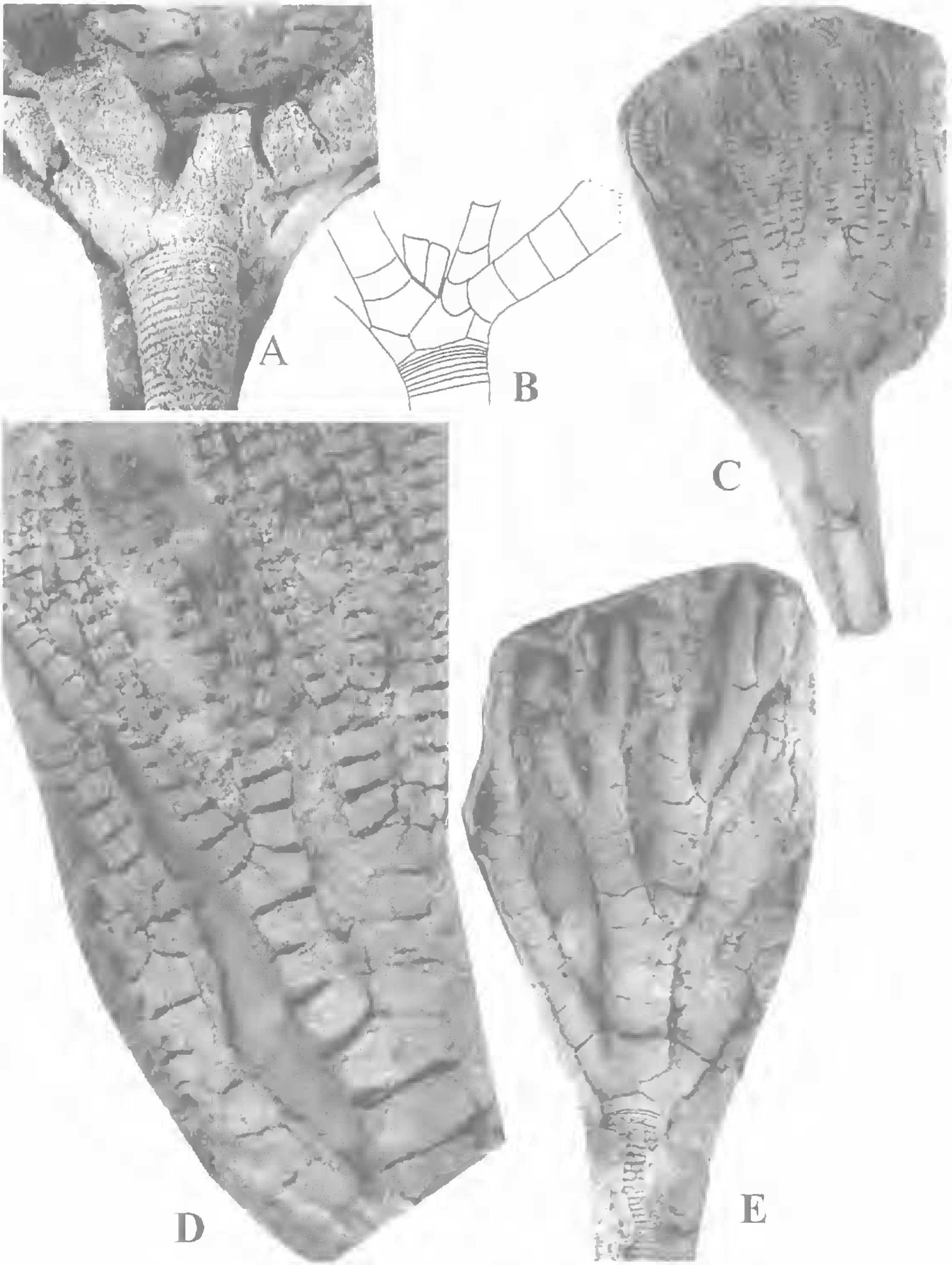


FIG. 83. *Meristocrinus quatriramus* sp. nov., large crown NMVP109765, from NMVPL1924. A, closeup of cup in posterior view, ×4. B, sketch of plate arrangement of A. C, posterior view of crown, ×1.5. D, interior of arms, ×4. E, anterior view of crown, ×2.

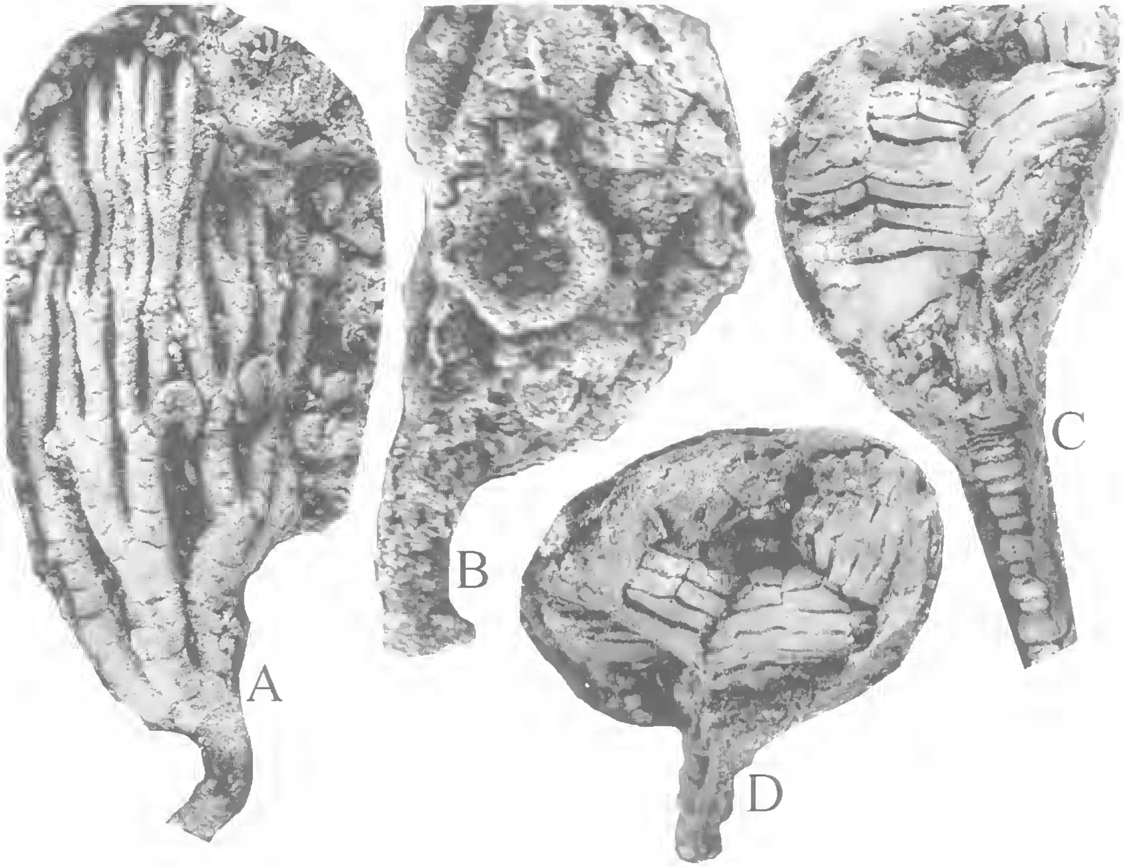


FIG. 84. A,B, *Quadritaxocrinus websteri* gen. et sp. nov., holotype crown NMVP149354 from NMVPL6601. A, E ray view, ×3. B, C ray view with circular columnal concealing CD interray above anal X, ×5. C,D, *Geroldicrinus* sp., crown NMVP149362 from NMVPL1990, ×3. C, lateral anterior view. D, distal view.

primibrachs in *Quadritaxocrinus* is not unexpected even if it is the first record of such increase in the Taxocrinidae.

Quadritaxocrinus websteri sp. nov.
(Fig. 84A, B)

ETYMOLOGY. For Gary D. Webster, Washington State University who provided many useful discussions on crinoids.

MATERIAL. HOLOTYPE: NMVP149354 from NMVPL6601.

DIAGNOSIS. As for genus.

DESCRIPTION. Crown 35mm long. Infrabasals concealed by stem. Basals not clearly defined but probably 5, wider than long; CD basal irregular in shape, with projection extending up between C and D radials. Radials pentagonal, with plenary facets. Arms long, dividing isotomously on 4th primibrach, with next division at secundibrach 4 producing unequal branches, with 3rd and 4th divisions at different levels, without interprimibrachs. Stem circular in section, widest proximally, of short, strongly crenulate columnals proximally.

REMARKS. The only available specimen is not clear in definition of the cup plates but the proximal and distal margins of the basals, with the posterior basal extending up between the C and D radials and outline of the radials are clear.

Order SAGENOCRINIDA Springer, 1913
Family LECANOCRINIDAE Springer, 1913

Geroldicrinus Jaekel, 1918

TYPE SPECIES. *Lecanocrinus roemeri* Schultze, 1867 from the Middle Devonian of Germany.

Geroldicrinus sp.
(Fig. 84C, D)

MATERIAL. NMVP149362 from NMVPL1990.

DESCRIPTION. Crown 15mm long, egg-shaped but truncated distally, crushed and therefore, not useful in comparing dimensions. Cup, conical, of smooth plates, but only the distal part of 1 anterior radial available. Infrabasals and basals not evident. Arms plenary, with 1st primibrach axillary, with 1 further division at different levels in same ray, closely abutting each other laterally, strongly incurved distally to fully enclose a space distal to the cup. Stem circular in section, of short columnals proximally, becoming longer and heteromorphic distally.

REMARKS. Even though anal plating at the posterior and the lower cup are not available crown shape, arm branching and structure and particularly the axillary 1st primibrach are sufficient to identify this genus. Since Schultze (1867) described this genus it has not been recognised elsewhere and so this single specimen from Victoria is a significant range extension.

STEM ONLY

Group PENTAMERATA Stukalina, 1966
Order STRIALATA Stukalina, 1978
Family DECACRINIDAE Yeltyschewa, 1957

Decacrinus Yeltyschewa, 1957

TYPE SPECIES. *Decacrinus pennatus* Yeltyschewa, 1957 from the Lower Devonian of central Kazakhstan.

Decacrinus sp.
(Fig. 85)

MATERIAL. NMVP149353 from NMVPL1924.

REMARKS. This form genus is distinctive in having 5 grooves radiating from the central canal towards the 5 outer angles of the stem as well as 5 shorter but wider grooves radiating from the central canal towards the middle of each side of the stem. Stukalina (1986) recorded this genus in the Early Devonian (Gedinnian and Siegennian) which is the same age as the Australian specimen. Species identification of the Australian specimen is not attempted because it does not fit easily into a known species and I am reluctant to erect a new one on a single specimen without knowing the crown it supported. The projections at the 5 angles are very reminiscent of the stem of Pterinocrinidae gen. nov., described above, from the Lilydale area but preservation of that specimen is not good enough for certain identification.

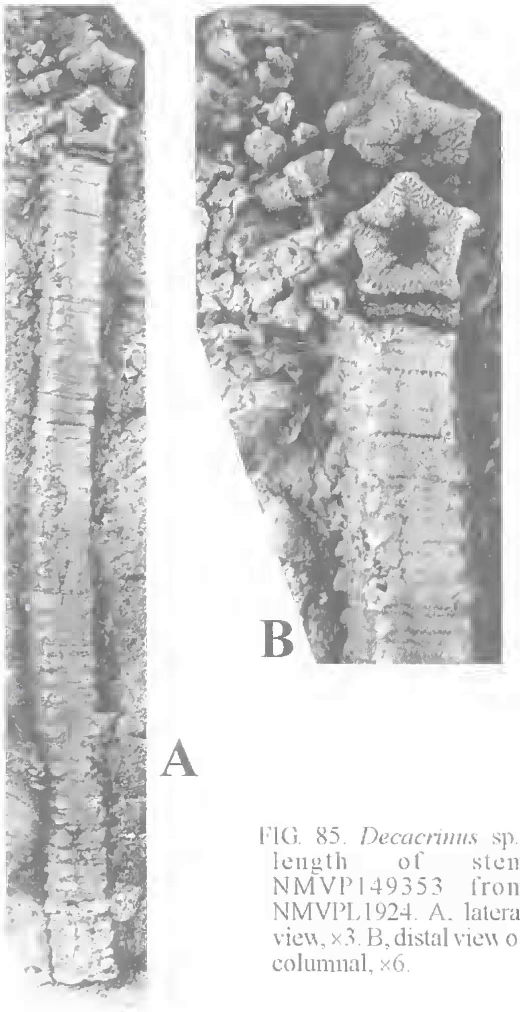


FIG. 85. *Decacrinus* sp., length of stem NMVP149353 from NMVPL1924. A, lateral view, ×3. B, distal view of columnal, ×6.

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APPENDIX

List of localities arranged in descending age and grouped as per the columns numbered 1-11 in Figure 1.

Column 11. Late *Boucotia australis* Zone (Late Lochkovian).

NMVPL229 Collins Quarry, on access road to youth camp about 2 km N of Tommy's Hut, Kinglake (=X0 of Williams, 1964)
Hollowaycrinus calvus
Eudimerocrinus eckardti
Oehlerticrinus lememi
Oehlerticrinus jeani
Frankocrinus holmesi
Ctenocrinus signatus
Ctenocrinus paucidactylus
Plumocrinus americanus
Antihomocrinus chapmani
Ancyrocrinus sp.
Kroppocrinus heathcotensis

NMVPL1924 sandstone bar across Mathieson's Creek about 1km S of Kinglake to Flowerdale Road and about 6km NE of Tommy's Hut (=T95 of Williams, 1964)
Duncanicrinus calvariolus
Eudimerocrinus eckardti
Ctenocrinus sp.
Myelodactylid sp.
Kroppocrinus mathiesonensis
Stewbreecrinus terryi
Antihomocrinus chapmani
Meristocrinus quatriramus
Decacrinus sp.

Column 10. Middle *Boucotia australis* Zone (Late Lochkovian).

Locality R52 of Thomas (1940), Unit 3 Mt Ida Fmn, Parish of Redcastle, N of Heathcote; see Talent (1965, fig. 1)
Holmesocrinus idaensis

Locality R25 of Thomas (1940), Unit 3 Mt Ida Fmn, Parish of Redcastle, N of Heathcote; see Talent (1965, fig. 1)
Crotalocrinites pulcher
Ctenocrinus paucidactylus

Column 9. Early *Boucotia australis* Zone (Late Lochkovian).

NMVPL252 Middendorp's Quarry, 2km E of Tommy's Hut, Kinglake (=W3 of Williams, 1964).
Dimerocrinites bispinosus
Eucrinus clarkae
Eudimerocrinus eckardti
Nexocrinus sp.
Duncanicrinus calvariolus
Oehlerticrinus lememi
Oehlerticrinus jeani
Frankocrinus enidae
Ctenocrinus paucidactylus
Ctenocrinus stellifer
Ctenocrinus signatus
Clematocrinus perforatus
Darraghcrinus tomi
Codiacrinus secundus
Dendrocrinus arrugius
Plicodendrocrinus australis
Antihomocrinus chapmani
Dictenocrinus ibaeypus

Rubbish tip on Watson's Road at Pheasant Creek, 6km E of Tommy's Hut, Kinglake West.
Duncanicrinus calvariolus

Column 8. Late *Boucotia janeae* Zone (Early Lochkovian).

NMVPL1990, Road cutting just N of intersection of Victoria Road and Coldstream West Road, 5km N of Lilydale, NE Melbourne.
Ophiocrinus unettae
Eudimerocrinus gilli
Ctenocrinus stellifer
Pterinocrinidae gen. nov.
Shintocrinus richi sp. nov.
Dictenocrinus remotus sp. nov.
Geroldicrinus sp.

Roadcutting on road (Yarra Road) to Wonga Park, just S of Bryson's Road.
Dictenocrinus sp. cf. *D. ibaeypus*

Column 7. Middle *Boucotia janeae* Zone (Early Lochkovian).

NMVPL1922 sewerage trench in Kimberley Drive, Chirnside Park, N of Maroondah Highway 3.5km W of Lilydale.
Hexacrinites chirnsidensis
Antihomocrinus chapmani
Ctenocrinus stellifer

Column 6. Early *Boucotia janeae* Zone (Early Lochkovian).

NMVPL1841 small excavation on ridge above Ruddock's Quarry (now filled in) W of Edwards Road, 300m NW of its intersection with Switchback Road, Chirnside Park
Cupulocrinus austrogracilis

Column 5. Late *Notoparmella plentiensis* Zone (Pridoli).

NMVPL1923 large roadcutting just N of Merriang on Woodstock to Wallan Road, 9km N of Woodstock, 40km N of Melbourne.
Holmesocrinus enidae

Nexocrinus wallanensis
Trichocrinus morleyi

NMVPL260 Excavations for Winneke Dam, 33km NE of Melbourne. (Jell & Holloway, 1983).
Duncanicrinus calvariolus
Kooptoonocrinus nutti
Dendrocrinus saundersi
Codiacrinus rarus

Column 4. Early *Notoparmella plentiensis* Zone (Late Ludlow).

NMVPL300 near disused mine on Comet Creek, c. 4.6km SE of Clonbinane, 60km N of Melbourne; (=X64 in Clonbinane Sandstone of Williams, 1964).
Clematocrinus perforatus
Alisocrinus lineatus
Plumocrinus hauschi
Dendrocrinus arrugius
Shiutocrinus cometensis
Antihomocrinus chapmani

NMVPL6601 on Boundary Road spur above Comet Creek Mine (NMVPL300), 4.6km SE of Clonbinane, 60km N of Melbourne.
Quadritaxocrinus websteri

Column 3. Late *Aegiria thomasi* Zone (Ludlow).

SW of Bald Hills, just E of railway, N of Sunday Creek Road, 5km E of Kilmore.
Dendrocrinus arrugius

NMVPL299 road cutting on Sunday Creek Road, 700m NE of junction with Saunders Lane, Kilmore East (=F31 of Williams, 1964).
Nassoviocrinus corcorani
Trichocrinus morleyi

Column 2. Late *Aegiria thomasi* Zone (Ludlow).

Yarra Improvement Works (refers to works to straighten the river between the South Yarra Railway Bridge and Princes Bridge, at the end of last century).
Hapalocrinus victoriae

NMVP1615, excavation on ridge on W of railway cutting c. 800m WSW of Royal Park Railway Station, Parkville, Melbourne
Plumocrinus americanus
Nassoviocrinus longibrachiatus
Trichocrinus morleyi

Quarry (now in Clifton Park) at West Brunswick between Albert and Victoria Streets.
Helicocrinus plumosus

NMVPL2259 in creek bed about 250m N of Heathcote-Nagambie Road, E of Argyle Railway Station, Heathcote (=H41 of Thomas, 1940).
Clematocrinus argylensis
Kroppocrinus heathcotensis
Nassoviocrinus corcorani

NMVPL1925 in creek bed under bridge (on Sunday Creek Road) just west of railway line at Kilmore East.
Dendrocrinus arrugius

Upper Yarra (no further details; grouped with other localities having this species).
Nassoviocrinus longibrachiatus

Excavation at E end of Melbourne CBD (presumably in area of Spring Street, possibly at Flinders Street intersection; exact locality unknown))
Hapalocrinidae indet.

Column 1. Middle *Aegiria thomasi* Zone (Ludlow).

NMVPL1927 at crossing of Broadhurst Creek by Kilmore to Wandong Road (Kilmore Siltstone).
Dendrocrinus sp.